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ANATOMICAL AND HISTOLOGICAL STUDIES OF THE FEMALE REPRODUCTIVE ORGANS OF THE AMERICAN SAW-FLY, CIMBEX AMERICANA, LEACH.

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(with plates iii to v.)

The material for the present paper was obtained in Milwaukee County, Wisconsin. The insects were collected during June and the early part of July usually from the peach-leaved willow (Salix amygdaloides Anders.) and the long-leaved willow (Salix longifolia Muhl.)

ANATOMICAL STRUCTURE OF THE FEMALE REPRODUCTIVE ORGANS.

The internal female reproductive organs of Cimbex occupy the greater part of the abdominal cavity. The paired ovaries, which embrace the dorso-lateral sides of the alimentary canal, are pale greenish in color and extend from the second to the posterior end of the seventh abdominal segment (Fig. 1, *ov*). Each ovary is made up of a large number of ovarian tubules arranged in a parallel manner. Anteriorly, these tubules taper gradually into the very fine thread-like terminal filaments, which are twisted together distally, thus holding the two ovaries together; posteriorly, the tubules of each ovary open into the funnel-shaped oviducts. The two oviducts unite in a forked manner below the alimentary canal to form the common oviduct or oviductus communis. In a dorsal view, the oviductus communis is almost entirely hidden by the spermatheca (Fig. 1, *sp*) and the large reservoir of the colleterial glands (Fig. 1, *cs*). The common oviduct terminates in the vaginal orifice, which is directly below the peculiar notch of the last sternite and the base of the ovipositor (Fig. 16, *vo*).

The spermatheca in the living condition is of a pale yellowish color, but in the material injected with 95 per cent. alcohol, it assumes a whitish color. From an external view, a constriction divides the seminal receptacle into two parts: (1) a more or less heart-shaped dorsal part (Fig. 1, *sp*); and (2) a funnel-shaped ventral portion, which opens into the dorsal wall of the common oviduct (Fig. 18, *f*). This boundary is further marked by two bundles of transverse muscles, which leave the spermatheca on either side and attach to the body wall. The musculature of the spermatheca and the function of these will appear in a subsequent paper.

In order to ascertain the exact course which the male intromittent organ takes during copulation, the abdomen of a number of specimens was cut in two during the sexual union and then dropped into 95 per cent. alcohol. If, after thorough dehydration, the abdomen of the male and female are separated, the opening in the female for the reception of the male organ can be distinctly seen to be directly beneath the peculiar notch of the last sternite (Fig. 16, *vo*). A careful dissection of the abdomen of two specimens obtained in this manner shows that the male copulatory organ passes not only into the common oviduct, but extends for some distance up into the funnel-shaped portion of the spermatheca.

The accessory glands consist of a mass of coiled tubes lying for the greater part dorsal and lateral to the colleterial sac and spermatheca. A dissection of an insect immediately after it has been killed, shows that the accessory sac and glands are filled with a rather thick translucent liquid. With the addition of alcohol this liquid hardens, forming a whitish solid. In Fig. 1, the accessory glands were teased away from the reservoir and receptaculum seminis. These glands, when they are spread apart, are found to be composed of a right and left mass of branching tubules, which terminate blindly in slightly swollen ends. The branching tubules composing these masses finally communicate with two long unbranched ducts, the right and left accessory gland ducts. These ducts, in turn, unite a short distance before joining the colleterial sac, forming a broad duct, the common colleterial gland duct, which communicates with the reservoir posteriorly (Figs. 17 and 18, *ccd*). The colleterial reservoir is a large slightly bilobed sac (Fig. 1, *cs*) which opens to the outside at the base of the saws by a broad, somewhat obliquely inclined duct (Figs.

13 and 18, *d*). Near the opening of the duct are two bundles of transverse muscles, which leave the dorsal wall of the duct and attach to the basal margin of the sheaths of the saws (Figs. 13 and 17, *tm*). Dorsally, the colleterial duct is in continuation with two lobes (Fig. 13, *dl*) which, in turn, are in continuation with the membrane that lines the inner surface of the saws. Ventrally, the wall of the duct terminates in a large fold (Figs. 13 and 18, *vf*). The duct of the colleterial sac thus opens out between the two dorsal lobes and the large ventral fold (Fig. 13, *d*).

When the spermatheca and colleterial sac are carefully pulled away from each other, there is revealed a triangular chitinous plate, which rests upon the dorsal wall of the oviductus communis. To this plate several bands of muscle attach (Fig. 13, *tp*).

HISTOLOGICAL STRUCTURE OF THE FEMALE REPRODUCTIVE ORGANS.

Ovaries: Each ovary is made up of a variable number of ovarian tubules or ovarioles, there being usually between twenty and thirty. In six specimens dissected, the number of ovarian tubes in the entire ovary was neither constant nor equal in either ovary, as is shown by the following figures:

	Ovarioles in Right Ovary.	Left Ovary	Total in Both.
	28	23	51
	21	23	44
	27	25	52
	25	27	52
	25	24	49
	30	28	58
Average,	26	25	51

When the lowest egg in each tubule is ripe or nearly so, it is elongated more or less ovoid in shape with the distinction between dorsal and ventral surfaces indicated by a difference in curvature. After the lowest egg in each ovariole has passed out of the egg-tube, each tubule appears to be supported upon a stalk which opens into the oviduct. Alternating with each egg-chamber is a nutritive or yolk-compartment, the latter being distinguishable from the former with the naked eye only at the basal end of the ovarian tubule by its smaller size. The nutritive chamber, which is anterior to the basal egg, is usually smaller (Fig. 1, *nc*) than the one between the next two eggs. Towards the distal end of the ovariole, however, egg-chambers and yolk-chambers cannot be distinguished as such with the naked eye by a difference

in size. The tip of the egg-tube passes over gradually into the terminal chamber, which, in turn, passes over into the terminal filament.

A histological study of the wall of the egg-tube shows that it is covered externally by a peritoneal membrane, in which anastomosing, transversely-striated muscle fibres are embedded. Toward the distal end of the ovariole, the peritoneum is especially well developed, while posteriorly it gradually becomes thinner. The anastomosing muscles extend to the apex of the ovariole, being present in even the terminal filament. Within the peritoneum is a basement-like membrane; this membrane is sometimes distinctly visible between the nutritive and egg-chambers.

Oviduct and Oviductus Communis: In general, the histological structure of the oviduct will hold good also for the oviductus communis anterior to the spermatheca. The following layers, passing from within outward, are present: (1) a chitinous intima; (2) an epithelial layer; (3) a longitudinal muscle layer; (4) a circular muscle layer; and (5) a peritoneal membrane (Fig. 5).

When no eggs are present in the oviduct or oviductus communis, their wall is thrown into folds which are nearly filled with longitudinal muscles (Fig. 5, *lm*). The chitinous intima varies but little in thickness throughout the entire genital duct; such variations as occur are found directly beneath the egg-tubes, where the chitin is extremely thin and hardly perceptible. A surface view of this intima shows the presence of long, yellowish, chitinous bristles which are not distributed uniformly, but are clustered in groups (Figs. 3 and 5, *b*). The epithelial cells, with cell boundaries usually indiscernable, contain a large ovoid nucleus embedded in a slightly granular cytoplasm. External to the epithelial layer are the longitudinal muscles, which are somewhat better developed than the circular muscles just outside of these.

Spermatheca: A longitudnial section through the spermatheca shows that the structure of the chitinous intima is somewhat similar to the chitinous integument which Folsom (16) described for most insects. He writes: "The chitinous integument (Fig. 88) of most insects consists of two layers: (1) an outer layer, homogeneous, dense, without lamellae or pore canals, and being the seat of the cuticular colors; (2) an inner layer, 'thickly pierced with pore canals, and always in layers of different refractive indices and different stainability.' (Tower.) These two

layers, respectively *primary* and *secondary* cuticula, are radically different in chemical and physical properties." In the heart-shaped dorsal part of the spermatheca numerous pore canals, which stain deeply with gentian violet, penetrate the hyaline lamellated secondary layer of chitin in a more or less wavy manner (Figs. 4 and 7, *c*). They could, in some cases, be seen to enter the deeply staining primary layer, but could not be traced for any great distance here. In the funnel-shaped ventral portion of the spermatheca the pore canals could not be found.

A number of microscopic differences occur in the two divisions of the spermatheca. In the dorsal region of the heart-shaped part, the primary layer of chitin is smooth and entirely free from bristles (Fig. 7, *p*). At some distance dorsal to the constriction, which marks the boundary between the two divisions of the spermatheca, there are a few sharply pointed bristles scattered about irregularly (Fig. 4, *b*). Near this boundary the primary layer of chitin assumes a folded appearance with the bristles regularly arranged on one side of the fold and pointing ventrally (Fig. 4, *v*). At the constriction, however, the bristles change in direction and point dorsally and they are here arranged on the opposite side of the fold (Fig. 4, *a*). The bristles retain this position throughout the funnel-shaped ventral portion of the spermatheca.

In the dorsal heart-shaped region of the spermatheca the epithelium consists of prismatic cells, where cell boundaries are discernable, while in the funnel-shaped portion the inner ends of the cells vary somewhat in shape, owing to the folding of the chitinous intima. The cytoplasm in the dorsal and throughout the greater part of the ventral divisions of the spermatheca is granular towards the chitinous intima, but towards the basal end, the epithelial cells show a distinct longitudinal striation. Each cell contains an ovoid nucleus with its long axis at right angles to the chitinous intima (Fig. 7).

Near the region where the spermatheca opens into the common oviduct, the epithelial cells gradually become smaller and more or less flattened. The long axis of the ovoid nuclei usually assumes a direction parallel to the chitinous intima. The marked longitudinal striation has disappeared, and the cytoplasm is granular throughout these cells. Both primary and secondary layers of chitin are very much thinner, but the bristles are of the same size and still point dorsally (Fig. 2).

The transition from the spermatheca to the common oviduct is not difficult to determine, the chitin of the former losing its regularly folded appearance, and becoming more or less irregularly folded in the latter. The bristles, which in the spermatheca were regularly arranged on one side of the folds, do not have this uniform arrangement in the oviductus communis, but are clustered in groups (Fig. 3, *b*).

Accessory glands and sac: A study of sections cut through the accessory glands and ducts shows them to consist of the following layers, passing from within, outward: (1) a chitinous intima; (2) the so-called "endothelial or centro-tubular cells" of Fernard (15); (3) an epithelial layer; (4) a basement membrane; and (5) a peritoneal membrane.

Each cell of the accessory glands contains a so-called "vésicule sécrétante or vésicule intracellulaire" of Dierkx (13) or "vésicule radiée" of Henneguy (18). This vesicle is more or less oviform in shape and oftentimes strands of cytoplasm radiate from it (Fig. 9, *vr*). A small chitinous canal [canalicule intravésiculaire of Dierkx (13)] leaves the vesicle, follows a sinuous path to the chitinous intima, which it penetrates, and opens out into the lumen of the gland (Fig. 9, *c*). This canal, or its contents, stains with gentian violet and to a slight extent with haematoxylin. The nucleus is found in the basal half of the cell usually close to the vesicle.

The "endothelial or centro-tubular cells" are represented in Cimbex by nuclei, which are usually crowded against the chitinous intima (Fig. 9, *en*) or wedged in between the inner ends of two glandular cells.

A comparison of a transverse section through the accessory glands with a similar section cut through the right or left colleterial gland duct or the common colleterial gland duct shows some marked differences. The sections show a different stainability, especially with the triple stain. The cytoplasm of the accessory gland cells stains deeply and the vesicle with its canal cannot usually be distinctly seen; in the ducts, however, the vesicle with its canal is well defined, the cytoplasm stains less deeply and shows a distinct longitudinal striation towards the basal end of the cells, but near the chitinous intima this striation is gradually lost and the cytoplasm becomes more homogenous (Fig. 10). In the accessory glands the large nucleus is spherical in shape and is found in the basal region of the cell, while in the ducts the more

or less ovoid nucleus varies in shape and may often be found between the vesicle and the outer boundary of the cell (Fig. 10) or nearer the central part of the cell. In the accessory glands the cell boundaries are very distinct (Fig. 9) but in the ducts these are indiscernable (Fig. 10). The cells of the glands are somewhat larger than those of the duct; the former surround a rather small central lumen, while the lumen of the duct is much larger.

The nuclei of the "endothelial or centrotubular cells," which are usually crowded up against the chitinous intima or wedged in between the inner ends of the two glandular cells in the accessory glands, are found midway in the epithelial layer in the ducts (Fig. 10, *en*). They can be distinguished easily from the nuclei of the epithelial cells by their smaller size.

All of these facts would tend to show that the cells of the right and left colleterial gland ducts, as well as the common colleterial gland duct, have either been emptied of their secretion, or that they have lost their power of secreting. As, however, quite a number of sections were cut through these ducts, and all showed the same structure we are inclined to believe that the cells have given up the secreting function and that the "endothelial or centro-tubular" nuclei have migrated from the position close up against the chitin to one between the cells. To definitely decide this point one would have to work probably with the pupae or larvae.

The histological change from the common colleterial gland duct to the accessory reservoir is rather abrupt. An outer, irregularly branching muscle layer makes its appearance upon the reservoir. The vesicles with their canals and the "endothelial or centro-tubular" nuclei gradually disappear in the sac (Figs. 8 and 11). A noticeable change in the epithelium is also apparent. In the common colleterial gland duct, the cytoplasm shows a distinct longitudinal striation toward the basal end of the cells, but near the chitinous intima the cytoplasm becomes granular; in the accessory sac, however, the cytoplasm is distinctly granular throughout the cell (Fig. 11). The epithelial cells of the colleterial reservoir vary in size, owing to the numerous, small, irregular folds into which the wall is thrown. Sharply pointed spines are present in the sac; these are especially numerous near the entrance of the common colleterial gland duct into the sac, and at the region where the latter passes over into its duct (Fig. 12, *sp*).

A series of transverse sections of the duct of the colleterial sac, shows the presence of a large ventral fold, which is partly filled with muscles and grooved at its middle (Figs. 14 and 15). The epithelial layer is somewhat better developed around this fold than at any other part of the duct. Around this fold the long axis of the ovoid nucleus is at right angles to the chitinous intima, but to either side of the fold, they gradually change their position and assume a direction more or less parallel to the intima (Figs. 14 and 15, *n*). The chitin lining the lumen is extremely thick. Near the opening of the duct are two bundles of transverse muscles which leave the chitinous intima and attach to the basal margin of the sheaths of the saws (Fig. 14, *tm*). These muscles when they contract, aided probably with the elasticity of the thick chitinous intima, close the duct.

A longitudinal section of this same duct shows that the muscles which, as already described from a cross section, partly fill up the large fold, can be traced over from the colleterial sac. Within the fold they spread out fan-like and attach to the chitinous intima (Fig. 12). These muscles when they contract open the duct.

A closer examination of the longitudinal section shows that the wall of the large ventral fold (Fig. 18, *vf*) when traced to the region where the duct opens out, bends upon itself and is continuous with the dorsal wall of the common oviduct. The chitinous intima of the large ventral fold decreases gradually in thickness toward the opening of the duct, and bending upon itself, continues as a layer of chitin of almost uniform thickness to the triangular chitinous plate. (Fig. 18, *chp*) which, as already described, rests upon the dorsal wall of the common oviduct between the spermatheca and colleterial sac. Projecting here and there from this chitinous intima near the opening of the duct of the sac, are long, yellowish bristles. Besides these bristles, large multinucleated glands with a pore canal penetrating the chitinous intima in their neighborhood and peculiar sense organs are scattered between the epithelial cells.

These sense organs project as papillae from the chitinous intima, and are very evident when the colleterial sac duct is mounted *in toto*. At the distal end of these papillae is a ring of chitin enclosing a circular opening. This ring of chitin stains with gentian violet. The papilla is in connection with a clear bladder-like structure, which is surrounded by a somewhat granular pro-

toplasm containing one or more nuclei. Within the clear bladder-like structure is a cone [Achsencylinders of Will (32)] which gradually becomes thicker toward its basal portion. From the basal region of the sense organ a nerve is given off.

The epithelium, when traced from the region where the duct of the colleterial sac opens out, to the triangular plate, is seen to be represented by cells which are somewhat wider than long, with their basal ends more or less rounded. Anterior to the triangular plate, however, there is an abrupt cellular change; the epithelial cells, as already mentioned in the description of the cellular change between the spermatheca and common oviduct, are extremely flattened and are represented chiefly by ovoid nuclei, which are arranged parallel to the chitinous intima (Fig. 3).

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EXPLANATION OF PLATE III.

All figures except general dissections were drawn with a camera lucida.

FIG. 1. Dissection showing dorsal view of reproductive organs with left ovary removed: *ov*, ovary; *nc*, nutritive chamber; *od*, oviduct; *cod*, oviductus communis; *sp*, heart-shaped part of spermatheca; *acg*, accessory glands teased apart; *cs*, colleterial sac; *m*, muscle bundles of saw; *s*, sheaths of saw. (x4.)

FIG. 2. Longitudinal section of cells through the funnel-shaped portion of the spermatheca near the region where it opens into the common oviduct: *ep*, epithelium; *b*, bristle; *p*, primary layer of chitin; *s*, secondary layer of chitin. (x647).

FIG. 3. Longitudinal section of the dorsal part of common oviduct posterior to the entrance of the spermatheca: *ep*, epithelium; *ch*, chitinous intima; *b*, bristles. (x900.)

FIG. 4. Longitudinal section of the chitinous intima of the spermatheca, showing the change in direction of the bristles at *a*, near the constriction *e*, which divides the spermatheca into the heart-shaped dorsal portion and the funnel-shaped ventral part: *v*, bristle near the constriction and pointing ventrally; *d*, bristle below constriction and pointing dorsally; *b*, bristle dorsal to the constriction, these bristles being arranged irregularly upon the unfolded chitin; *p*, primary layer of chitin; *s*, secondary layer of chitin; *c*, pore canal. (x520).

FIG. 5. Cross section of a fold of the oviduct with the peritoneum not shown: *ch*, chitinous intima; *b*, bristles; *ep*, epithelium; *lm*, longitudinal muscles; *cm*, circular muscles. (x647).

FIG. 6. Longitudinal section of the cells of the colleterial sac: *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x867.)

FIG. 7. Epithelium and chitinous intima of the dorsal region of the heart-shaped part of the spermatheca: *p*, primary layer of chitin; *s*, secondary layer of chitin; *c*, pore canal; *ls*, longitudinal striations of cytoplasm. (x647.)

Fig. 1.

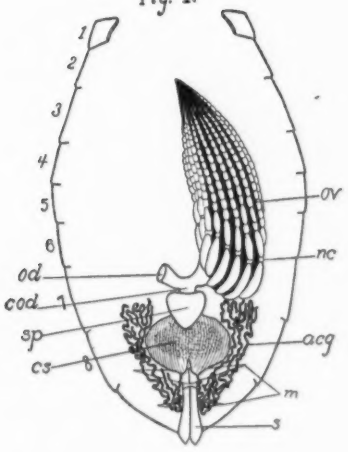


Fig. 2.

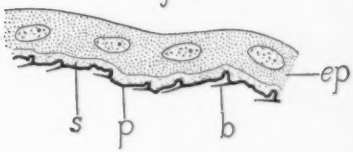


Fig. 3.

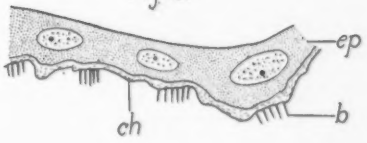


Fig. 5.

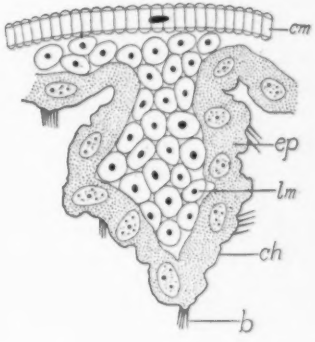


Fig. 4.

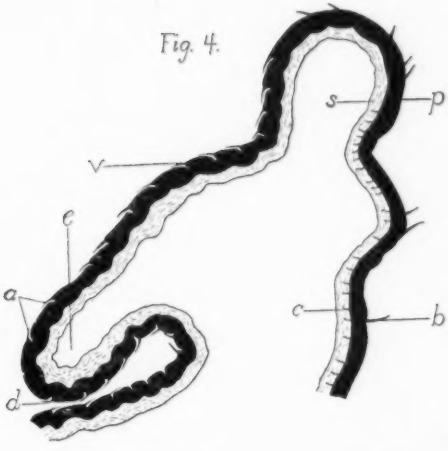
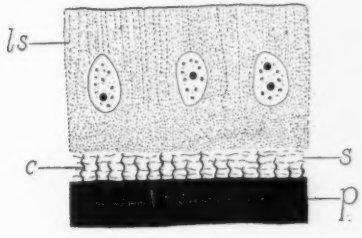


Fig. 7.



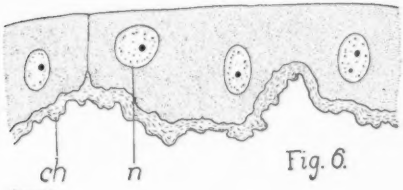


Fig. 6.

Severin.

EXPLANATION OF PLATE IV.

FIG. 8. Longitudinal section through the common colleterial gland duct and colleterial sac, showing the opening of the former into the latter: *o*, opening of the common colleterial gland duct into the colleterial sac; *sp*, spine; *en*, "endothelial or centro-tubular" nucleus; *n*, epithelial nucleus of the colleterial sac; *c*, canal of "vésicule radiée"; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire". (x307.)

FIG. 9. Cross section of cells of the colleterial glands: *ch*, chitinous intima; *en*, "endothelial or centro-tubular" nuclei; *c*, canal of vesicule radiée; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire". (x647.)

FIG. 10. Longitudinal section of cells of the common colleterial gland duct: *ch*, chitinous intima; *c*, canal of "vésicule radiée", *en*, "endothelial or centro-tubular" nucleus; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire"; *ls*, longitudinal striations of cytoplasm; *g*, granular cytoplasm. (x900.)

FIG. 11. Longitudinal section showing the cellular change between the common colleterial gland duct and colleterial sac: *ch*, chitinous intima; *c*, canal of "vésicule radiée"; *en*, "endothelial or centro-tubular" nucleus; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire"; *ep*, nucleus of epithelial cell; *ls*, longitudinal striations of cytoplasm; *g*, granular cytoplasm; *a*, transition of epithelium of duct to that of sac; *s*, spine; *m*, muscles. (x647.)

FIG. 12. Longitudinal section of the colleterial sac duct: *se*, secretion; *sp*, spine; *ch*, chitinous intima; *m*, muscles of sac that pass into the ventral fold of duct and, spreading out fan-shape, attach to the chitinous intima. (x120)

Fig. 8.

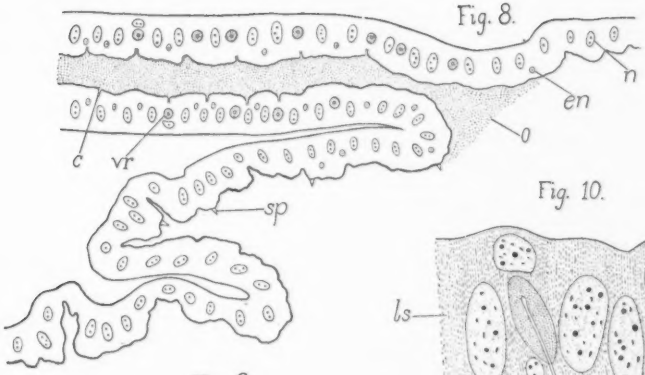


Fig. 10.

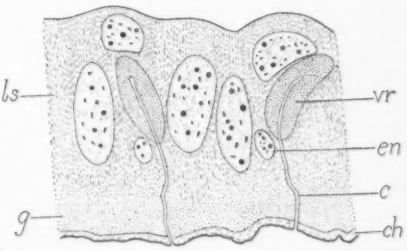


Fig. 9.

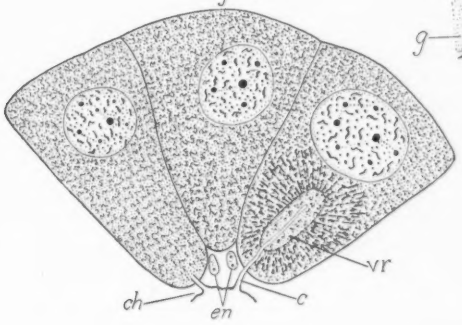
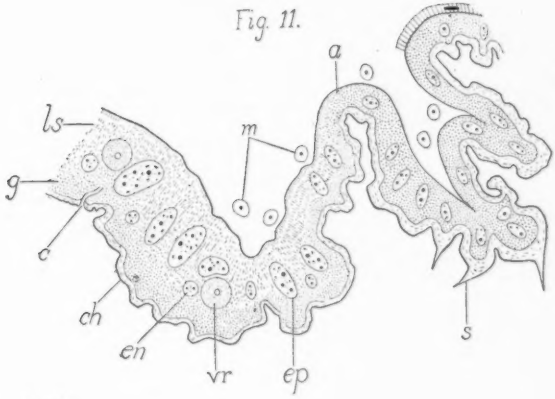


Fig. 12.

Fig. 11.



Severin.

EXPLANATION OF PLATE V.

FIG. 13. Ventral view of saws spread apart, showing the opening of the colleterial sac duct at *d*: *tp*, triangular chitinous plate to which bundles of muscles attach; *vf*, ventral fold; *dl*, lobes that are in continuation with the colleterial sac duct dorsally; *tm*, bundle of transverse muscles which leave the colleterial sac duct dorsally and attach to the basal margin of the sheaths of the saw; *ch*, chitinous intima of colleterial sac duct, to which the transverse muscle fibres attach; *t*, teeth of saw. (x12).

FIG. 14. Cross section of the colleterial sac duct near its opening, showing the attachment of some of the transverse muscles to the dorsal wall of the duct: *tm*, transverse muscle bundles; *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x175.)

FIG. 15. Transverse section of colleterial sac duct nearer to the sac than figure 14, showing the ventral median-groove: *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x175.)

FIG. 16. Last sternite showing the vaginal orifice, *vo*. (x6½.)

FIG. 17. Posterior view of colleterial sac: *cd*, colleterial gland duct; *ccd*, common colleterial gland duct; *o*, opening of common colleterial gland duct into the colleterial sac; *tm*, bundles of transverse muscles which leave the duct and attach to the basal margin of the sheaths of the saws; *l*, lobes that are in continuation with the colleterial sac duct dorsally.

FIG. 18. Diagram showing the common oviduct, spermatheca and colleterial sac with their openings: *cod*, common oviduct; *sp*, heart-shaped part of spermatheca; *f*, funnel-shaped part of spermatheca; *o*, opening of spermatheca into the dorsal wall of the common oviduct; *chp*, triangular chitinous plate; *cs*, colleterial sac; *ccd*, common colleterial gland duct opening into the colleterial sac; *d*, duct of colleterial sac, which opens between the saws; *s*, opening of common oviduct; arrows in the common oviduct indicate the path which the eggs take; the eggs thus pass beneath the opening of the spermatheca at *o*, and, after passing out of the vagina, are received by the saws at *s*. (x20.)

Fig. 13.

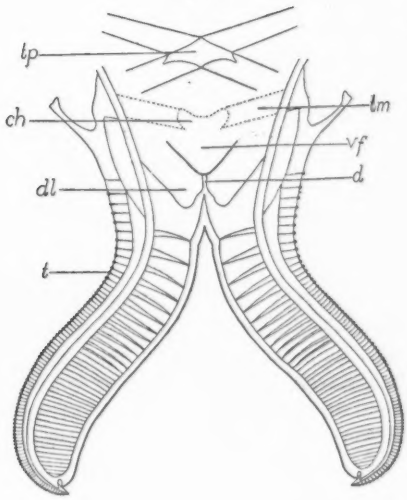


Fig. 14.

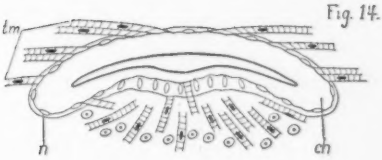


Fig. 15.

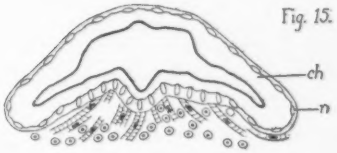


Fig. 16.

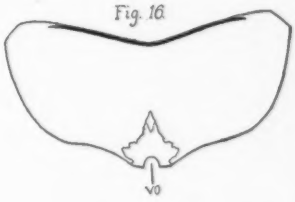


Fig. 18.

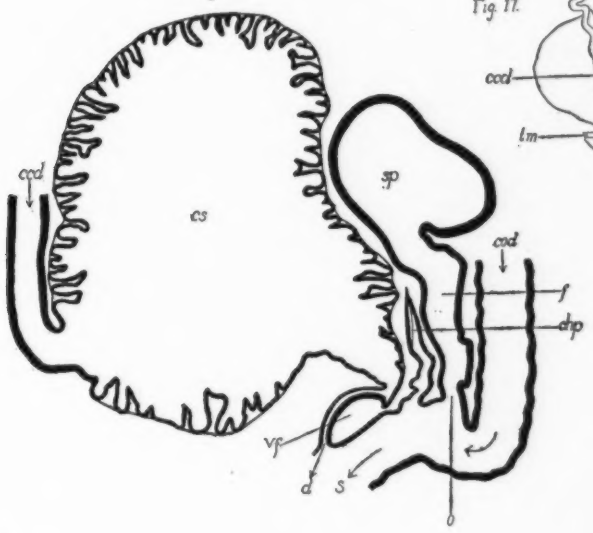
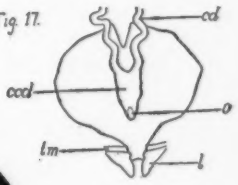


Fig. 17.



Severin.

SOME PROBLEMS IN NOMENCLATURE.*

By E. P. Felt.

Stability of nomenclature is greatly to be desired. It is, in our estimation, more important than that an investigator should have every particle of credit for discovering or recording the presence of a species, though the latter should not be ignored by any means. Certain peculiar questions in nomenclature exist in the Cecidomyiidae, a group in which we are much interested. It is hoped that this paper will provoke discussion and result in an agreement which will go far towards solving some vexatious questions. We desire at the outset to make this discussion absolutely impersonal, and for that reason the writer has taken the legal impersonal John Doe and some of his cousins to exemplify actual conditions or to illustrate situations which might arise. No significance should be attached to the dates employed, since they have no reference to real cases. Furthermore the names employed are *nomina nuda* and have no standing in nomenclature.

Case 1.

1475. Cecidomyia floricola—Given by John Doe to yellowish Cecidomyiid larvae in unopened spiraea blossoms.

1478. Cecidomyia floricola, C. flavescens and Dasyneura abdominalis—All reared from the same blossoms by Edward Doe.

To what species did the larva observed by John Doe in 1475 belong? Can he, by any possibility, claim authorship to a species?

Case 2.

1492. Cecidomyia gallicola—Described from the gall only, by John Doe.

1499. Cecidomyia gallicola—Adult reared and described by John Doe.

Does the species date back to 1492 and that name carry? We will suppose, for the sake of argument, that it does. Fortunately or unfortunately Richard Doe in 1575 discovered that Cecidomyia gallicola (John Doe 1499) is not the maker of the gall but an inquiline. He describes the maker of the gall as Lasioptera gallicola (John Doe 1492) and proposes for Cecidomyia gallicola (John Doe 1499) Cecidomyia alboscuta. Furthermore,

*Read at the Chicago meeting.

Edward Doe in 1575, though a few months later, reared still another species from this same gall. He likewise concludes that he has the true gall maker and describes it as Dasyneura gallicola (John Doe 1492). It happens that both the Lasioptera and the Dasyneura may produce this gall. Again we must ask the question: Can the gall carry the name? It is evident in this case that the systematic name, the one appearing in a catalogue listing the species of this family, is based and must of necessity be based on the characters presented by the adult. There are cases where two species belonging to the same genus may be bred from the same gall. Is there a Solomon present who can inform us which species shall bear the name earlier bestowed upon the gall? The situation is further complicated by the fact that it is very easy to rear Cecidomyiidae from some portion of a plant supposedly uninfested, as for example, apparently normal flowers, leaves or even stems.

CASE 3.

1496. Cecidomyia abstrusa—Gall described and the larva characterized by John Doe, so that it can possibly be referred to a genus.

1497. Lasioptera cincta—Collected at large and described by William Doe.

1499. Lasioptera abstrusa and L. splendens—Bred and described by Edward Doe.

Subsequent studies proved that both species may occur in about equal numbers in the gall. There are no characters given in the first description that can be relied upon to separate the larvae of the two forms. Was the species described in 1496, if so, what species? Furthermore, the adult described by Edward Doe as Lasioptera abstrusa in 1499, proves to be the same as the one William Doe collected and described in 1497.

There is little question as to what disposition should be made of case 1. A close examination of case 2 shows that ultimately the name must be carried by the adult. Would it not be in the interest of stability of nomenclature to accept the bestowal of the earlier names upon galls only in the spirit in which they were conferred; namely, as tentative pending the discovery and characterization of the imago? It is only a very little step farther to put in the same category, galls accompanied by a very brief description of the larva as illustrated in Case 3. We fully agree with the

suggestion that wherever possible the name bestowed upon the gall, should be given to the adult when reared therefrom. Unfortunately this is not always possible, since no one would for a moment allow that it was necessary to rear from a gall before describing the adult. It would be impossible and entirely impractical to attempt to enforce any such limitation, consequently sooner or later some decision must be made as to what constitutes a valid description in this group, as there are cases where species have been based on characters presented by the galls and subsequently the adults described. Despite the fact that we desire to be courteous to earlier workers and credit them with all due honor, nevertheless we must establish some standard in order to obtain a satisfactory working basis. The insistence that the true maker of the gall bear the same specific name as was originally bestowed upon the vegetable deformity it inhabits, will surely result in an almost unending series of unrivaled synonymical gymnastics, amusing though hardly edifying.

ON THE NERVOUS SYSTEM OF THE LARVA OF CORYDALIS CORNUTA L.*

By A. G. Hammar.

Owing to its large size and to the ease with which the parts may be dissected, the larva of Corydalis cornuta L. is especially favorable for the study of the nervous system. In spite of this fact, only fragmentary work has been done upon this species, and the present investigation was undertaken for the purpose of making a comprehensive study of the larval nervous system as well as for verifying the work already done.

Leidy '48 pictures and describes in a general way the nervous system of the adult insect, which in various respects differs from that of the larva. The only general discussion of the larval nervous system is that of Comstock and Kellogg '95. Though thoroughly accurate, this description is very concise, covering only the features of interest to the elementary student.

A detailed study of a limited region is that of Krauss '87, who confined his studies to the nervous system of the head of the larva. Although inaccurate in some details, his work is a valuable contribution to the knowledge of the nervous system and has been of much value to me in preparing this paper.

In 1895 an investigation was begun by Miss M. A. Nichols, for the purpose of determining the existence of a secondary nervous system such as that described by Newport '32 and '34. Unfortunately, this work was never finished, though promising interesting results. The notes and drawings were deposited in the entomological library of Cornell University, and in the study of certain features have been used to advantage by the writer.

For the material used, I am indebted to my friend, Mr. C. W. Palmer, of Westtown, Pa., who on different occasions has been kind enough to send me an abundant supply of living larvae from that locality. To Prof. J. H. Comstock I wish here to express my sincere acknowledgment for aid and encouragement liberally bestowed. For suggestions and aid received from members of the Entomological Staff of Cornell University, and most especially from Prof. W. A. Riley, under whose guidance this investigation has been carried on—I wish to express my sincere gratitude.

* Contribution from the Entomological Laboratory of Cornell University.

METHODS.

The usual methods of dissection were employed in making the preliminary studies of the nervous system. On account of the transparency of the tissues, however, it was found necessary to supplement the examination of fresh specimens with the study of stained or fixed specimens in which the nerves were more clearly differentiated. For such preparations alcoholic picric acid solution has been used to very great advantage. It stains and hardens the tissues rapidly, so that the preparation can be used almost without delay. The specimens when immersed for a longer time (2 – 3 hours) in water will destain, but they can be restained any number of times desired.

Alcoholic sublimate (Gilson's fluid) is very effective in differentiating the tissues. It must, however, be borne in mind that sublimate is very corrosive to metals, and a black precipitate is quickly formed, when metal pins or tools are used.

In tracing certain nerves *intra vitem* staining with methylene blue has been used to advantage, but since the different nerves take up the stain very irregularly*, much time and patience has been required to secure satisfactory results. The living larva was injected with approximately 1–2 cc. of the solution (½% methylene blue in normal salt solution). Half an hour later it was etherized and opened along the back and then spread out on a sheet of cork, exposing the visceral cavity. The still living tissues were kept moist with the above solution until the desired results were obtained. It sometimes requires 3-5 hours before certain nerves take up the stain. Once stained they will retain it for only a short time. By the application of a few drops of hydrogen peroxide solution (H_2O_2) the stain is intensified.

It was found that for some features a process of maceration could be used to great advantage. By soaking for several days in water considerable amount of muscular tissue is loosened and can be washed off easily by moving the preparation in water, leaving the more resistent nerves exposed and distinct. Similar results were brought about by the use of 5-10% nitric acid solution. In either of these two processes, the preparation must be afterwards hardened in alcoholic picric acid. These methods should first be used after a general study of the nervous system has been made.

* According to Ehrlich '86 (Biol. Centralb., VI, p. 214) the sensory nerves are the first stained, while the motor nerves require longer time.

INTRODUCTION.

The Corydalis larva, popularly known under the name of "dobson," "hellgrammite" or "crawler," is commonly found under stones at the bottom of swiftly flowing streams. Three years are required to complete the life cycle of the insect. The pupal and adult stages are of short duration, so that almost three years are required for the development of the larva.

This, when full grown, measures from 80 to 90 millimeters in length. It is rather oblong, depressed and tapering towards the posterior extremity. The entire body is dark brown or nearly black in color, with irregular markings on the chitinized portions of the head and thorax.

On either side of the head, caudad of the base of the antennae, there are six simple eyes. In very rare instances are there developed seven perfect eyes, the rudiments of the seventh being indicated by a light spot below the normal ones.

There are nine distinct abdominal segments, the last of which is provided with a pair of prolegs. The lateral borders of the first eight abdominal segments are pushed out into so-called lateral filaments. There is also a small pair of similar filaments to be found on the prolegs. On the ventral side of each of the first seven abdominal segments, there is a pair of large tracheal gills of a brush-like appearance. These are well supplied with tracheae, which ramify rapidly and send off branches, one to each separate thread-like portion of the gill.

As might be expected from the systematic position of the Corydalis, the nervous system of the larva is of a very generalized type. There is a ganglion for practically each segment of the body. Only in the last abdominal segments has there taken place a cephalization by the fusion of two or possibly three ganglia. The various ganglia of the central nervous system are connected longitudinally by two distinct nerve cords or connectives*, thus forming a chain, which extends on the ventral side throughout the length of the body. In the thorax and in the first abdominal segment, the ganglia are situated near the floor below the large ventral muscles, while the succeeding abdominal ganglia are all found above the same muscles.

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* In accordance with the suggestion of E. Yung '78, I have maintained the term *connectives* for the longitudinal nerve cords, while the term *commissure* has been used only for the transverse connections of symmetrical parts of the ganglia.

In the following consideration of the details of the larval nervous system I shall first take up the discussion of the central system, and follow this by a consideration of the so-called sympathetic system.

THE CENTRAL NERVOUS SYSTEM.

THE SUPRAOESOPHAGEAL GANGLIA OR BRAIN (Figs. 4 and 7, *b*, *b*). The so-called brain consists of two, large ovoid ganglia, situated dorsad of the oesophagus in the anterior portion of the head and immediately beneath the roof of the head, being protected only by a thin layer of connective tissue. The two ganglia are connected by a short, thick commissure, which in the drawing (Fig. 4) is indicated by the constriction between the two halves.

The dorsal portion of the anterior enlarged end of the aorta (Fig. 4, 7, *ao*) is attached to the caudo-ventral border of the brain.

In the brain of the Corydalis larva, the neuromeres—protocerebrum, deutocerebrum, tritocerebrum—are not so well differentiated as in the brain of Orthopterous insects studied by Viallanes **'87,** yet indications of the primitive ganglia constituting the brain are found in the form of basal enlargements of the optic, antennal, and the labral nerves which arise from the corresponding proto-, deuto-, and tritocerebrum. In the brain of the adult Corydalis, however, the neuromeres are more prominent than in the larva, the brain having undergone great modification during the pupal stage.

THE OPTIC NERVES (Fig. 4 and 7, *o*, *o*). The lateral borders of the brain are pushed out into the optic nerve trunks. A short distance from their origin, each trunk divides into seven slender nerves, each of which supplies an ocellus. As already stated, the seventh ocellus is generally rudimentary. The seventh nerve corresponding to this eye, however, is always present.

THE ANTENNAL NERVE (Figs. 4, 5, and 7, *a.a.*) This arises from the side of the brain ventro-cephalad of the optic nerve-trunk. The antennal nerve breaks up into three branches, of which the anterior main branch innervates the antenna. The second branch innervates the muscles of the antenna, situated at the base of the same. The basal branch, a rather slender nerve, originates near the ganglia and extends dorso-laterad.

THE CLYPEO-LABRAL NERVE (Figs. 4, and 7, *cl*). This together with the arched nerve (*ar*), originates as a single nerve trunk

from the base of the crus cerebri or more generally dorsad of the base of the crus cerebri. Under no circumstances could this nerve be considered as originating from the crus, since it is a well established fact that the nerve fibres of the labral nerve arise from the tritocerebrum.

At a distance of from one-half to one millimeter from its point of origin, the clypeo-labral nerve becomes separated from the arched nerve and projects cephalad into the clypeus and labrum, where it breaks up into six branches. The distribution of these is obvious from an examination of figure 4 and need not be discussed in detail. The relation of branch 3 to the sympathetic system is worthy of note.

In addition to the above described nerves of the supra-oesophageal ganglia there is to be found a pair of minute nerves which arise near the middle line of the caudal portion of the brain (Fig. 4.) These project dorso-caudad to the roof of the head.

THE CRURA CEREBRI (Figs. 2, 5, 7, *cr*). The crura cerebri consists of two large nerve cords connecting the supra- and sub-oesophageal ganglia and with them forming the so-called oesophageal ring. Each crus originates from the ventro-lateral border of the brain, turns ventrad around the oesophagus and enters the dorso-lateral border of the suboesophageal ganglion.

THE SUBOESOPHAGEAL COMMISSURE *(Figs. 2 and 7, *s.c*). Connecting the lower portions of the crura cerebri, and forming a semicircle round the ventral part of the oesophagus is the so-called suboesophageal commissure. This commissure, usually overlooked, has been found in a number of widely separated insects (for summary see Kolbe **'93,** pp. 411–413). In the most frequently cited instances this commissure originates from the brain, although a position similar to that of the Corydalis is reported for Libellula, Dytiscus, Carabus, Phryganea and various other insects.

From the suboesophageal commissure there are two cephalad projecting nerves, which innervate the upper longitudinal labial muscles (Fig. 2, *lm*).

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* Various names have been applied to this commissure. Thus, Lienard '80 calls it: *Les connexions transversales des commissures oesophagiennes;* Kolbe '93 *Quercommissure* or *Schlundring;* Edward Burgess '80: *Cross-nerve* or *commissure between the two hemispheres;* while Packard '98 refers to it as *transverse commissure of the oesophageal ring.* Since these terms are applicable only in limited groups it is preferable to use the term *suboesophageal commissure.*

THE SUBOESOPHAGEAL GANGLION (Figs. 2, 5, and 7, *s.g*). The suboesophageal ganglion is situated below the oesophagus in the anterior portion of the head. It is a rather large ovoid ganglion with its caudal portion terminating in the two connectives which pass back to the first thoracic ganglion.

From the suboesophageal ganglion there arise the following nerves:

THE MANDIBULAR NERVE (Figs. 4, 5, 6, and 7, *md*). The mandibular nerve arises as a large nerve trunk from the upper part of cephalo-lateral border of the suboesophageal ganglion. For a distance of a few millimeters it runs cephalad underneath the pharnyx, then it turns dorso-laterad until reaching the level of the optic and antennal nerves. Here it projects laterad, passing in front of the column-like apodeme (*ap*), where it divides into three branches.

Branch *1* bends caudad and innervates the large mandibular muscles. Branch *2* is quite short and slender, and connects the mandibular nerve with a minute ganglion (*g*). This ganglion has been observed in several specimens and probably forms a part of the sympathetic system. The third branch of the mandibular nerve has two prominent ramifications, of which the first, labeled *5*, enters the mandible while the second, marked *3*, runs laterad until approaching the outer condyle of the mandible, where it divides, sending off one anterior smaller branch to this part of the head and one larger caudal branch to the mandibular muscles.

Nerve *4* has not been found connected with the central nervous system. It and the ganglion (*g*) will be discussed under the sympathetic system.

THE MAXILLARY NERVE (Figs. 4, 5, and 7, *mx*). The maxillary nerve arises from the cephalo-lateral border of the suboesophageal ganglion. It is a rather large nerve trunk, projecting cephalad for the distance of a few millimeters, after which it breaks up into four branches (Fig. 5 *mx*.) The most proximal of these branches consists of a small nerve extending laterad to the base of the maxilla. The three remaining branches all originate from the same level shortly cephaled of the first branch. The two branches of the fourth, and also the anterior branch of the third, enter the maxilla. The second branch terminates in the enlarged basal portion of this organ.

THE LABIAL NERVE (Figs. 5 and 7, *1*). The labial nerve arises slightly ventrad of the maxillary nerve. It runs forward into the labium, where it gives off several branches. The first of these has three sub-branches, of which the proximal one projects mesad and innervates the ventral muscles of the labium; the second terminates in numerous branches near the lateral base of the labium; and the third projects to the latero-distal portions of the submentum.

Branch *2** arises cephalad of branch *1*, and runs mesad of the main nerve. Its termination has not been located definitely. Branch *3* innervates the lateral portions between the submentum and the mentum. Branch *4* supplies the distal border of the labium and branch *5* enters the labial palpus.

THE GUSTATORY NERVES (Fig. 5, *gn*). Projecting cephalad from the anterior border of the suboesophageal ganglion are two thread-like nerves which have been called by Krauss **'84** the *gustatory nerves*. They innervate the regions surrounding the opening of the salivary glands.

THE SALIVARY NERVES (Figs. 2, and 5, *sn*). The salivary nerves consist of two long thread-like nerves, arising shortly cephalad of the connectives from the caudo-lateral border of the ganglion. They project caudad, parallel to the connectives and enter the prothoracic cavity, where they turn laterad, branching off near the sides of the prothorax.

It is interesting to note that up to the present time the salivary glands of Corydalis have not been described. It was first through the tracing of the nerves and the determining of their homologies that I was lead to recognize the salivary duct, the so-called "*unknown nerves*" of Krauss **'84**.

THE VENTRAL NERVE of the suboesophageal ganglion (Fig. 5, *w*). Slightly caudad of the maxillary nerves there arise from either side of the ganglion a small much branched nerve, which innervates the regions below this ganglion. There is also a short branch given off to the salivary ducts.

THE MEDIAN NERVE (Fig. 5, *m. n*). The median nerve arising from the suboesophageal ganglion will be described under the sympathetic system.

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* Krauss, '84, figures this branch as innervating the salivary duct. (Fig. II, 7).

THE GANGLIA AND CONNECTIVES OF THE THORAX.

In the thorax (Figs. 1 and 2) there are three quite similar ganglia, which are the nerve-centers of the pro-, meso- and metathoracic segments respectively. These ganglia are situated near the floor, ventrad of the longitudinal-ventral muscles and caudad of the center of each respective segment. They are of relatively large size, circular in outline and decidedly depressed.

The first thoracic ganglion (*I*) is connected with the suboesophageal ganglion by two comparatively long connectives. On entering the prothorax they diverge as illustrated in Fig. 2.

The connectives of the two following segments are but half the length of those described above. They are also distinct from each other, enclosing between them the furcae (*f*) to which the ventral diagonal muscles of corresponding segments are attached.

THE NERVES OF THE FIRST THORACIC GANGLION (Fig. 1, 2, *I*). From either of the lateral borders of this ganglion there arise three nerve-trunks (*A*, *B*, *C*), the first and third of which are as large in diameter as the connectives. The anterior nerve trunk (*A*) extends laterad and breaks up into numerous branches which in Fig. 2 have been labeled: *a*, *1*, *2*, *3*; *b*, *1*, *2*, *3*, and *c*, *1*, *2*, *3*, *4*. The origin and direction of these nerves is evident from the illustrations and need not be described in detail. The second branch of *a* passes along the floor of the segment and innervates the neck. Branch *3* also follows the floor of the segment and extends to the caudal portion of the head. Nerve *b* supplies the latero-dorsal portions of the segment; branch *4* of nerve *c* runs cephalo-laterad, innervating the lateral portion of the neck.

Nerve *B* is relatively smaller than either *A* or *C*. It forks near its origin, giving the appearance of two distinct nerves. It innervates the ventral and lateral muscles.

Nerve *C*. The nerve of the leg consists of one large main trunk, which near its origin gives rise to a slender branch.

THE NERVES OF THE SECOND AND THIRD THORACIC GANGLIA (Fig. 2, *II*, *III*). The general distribution of the nerves of the above two ganglia is very much the same and therefore will be described together.

Nerve *A*, which in the larva is a rather small nerve, becomes in the adult quite enlarged and constitutes the *alar nerve*.

Nerve *B* resembles that of ganglion *I* except that it has an additional branch (*1*), which is analogous in appearance and distribution to "*a*" of nerve trunk *A* of the prothoracic ganglion.

Nerve *C*, as described under ganglion *I*, consists of two branches.

THE NERVES OF THE CONNECTIVES (Fig. 2, n_1c, n_2c, n_3c, n_4c). From the connectives of the thorax there arise four pairs of nerves of which the first two belong to the prothorax, the third to the mesothorax and the fourth to the metathorax. In their origin from the connectives, these nerves display quite a variation. The first pair may arise from the connectives either in the head or in the prothorax. The two nerves of a pair are not always directly opposite but may arise at different levels.

The nerves of the first pair arising from the connectives (n_1c) extend laterad for a short distance receiving branches from the transverse nerve of the sympathetic system. They then turn caudad between the large ventral muscles and terminate in the caudal regions of the prothorax.

The second pair (n_2c) arise from the connectives near the first thoracic ganglion. They extend laterad to the sides of the prothoracic segment.

The third (n_3c) pair of nerves originates slightly caudad of the middle from the connectives between ganglia *I* and *II*. They extend laterad, one on either side, and give rise to three branches, at the same level, 2-3 millimeters from the base of the main nerve. The first of these branches projects cephalad into the caudal regions of the prothorax; the second extends laterad passing under the large trachea and gives off at this point a slender branch which joins the tracheal nerve. As Fig. 2 shows, this tracheal nerve is connected with the transverse nerve of the sympathetic system; the third branch runs caudo-laterad and passes over the large trachea to the sides of the mesothoracic segment.

The fourth nerve (n_4c) originating between the meso- and the metathoracic ganglia, resembles the third and its branches have an analagous distribution and relation to the remainder of the nervous system.

THE ABDOMINAL GANGLIA* AND CONNECTIVES.

The abdominal ganglia consist of eight small ovoid nerve centers, situated below the alimentary canal and above the large ventral muscles. As a rule each ganglion is situated in the

* The modification of the first and eighth abdominal ganglia will be described separately.

anterior region of its segment. From above, the ganglia and the proximal portions of their nerves are protected by the ventral diaphragm, the outline of which is indicated in Figs. 1, *d*, *d*, by dotted lines.

The connectives of the abdominal ganglia consist of two distinct cords connecting the successive ganglia. Those of the first and last ganglia are very short because of the cephalization in these regions. The cephalic ends of the connectives are generally closely approximated, while the middle and caudal portions are slightly spread apart, so that the minute median nerve of the sympathetic system becomes exposed between the two connectives. In the abdomen there are no nerves arising from the connectives, such as were found in the thorax.

The Nerves of the Abdominal Ganglia.

The nerves arising from the first seven ganglia are pretty nearly uniform both in number and distribution. Fig. 3, representing the right side of the third segment, illustrates the typical condition of the nerves of the abdominal region. From each ganglion two sets of nerves arise, one pair lateral and one pair ventral.

The lateral nerve (*l*) extends laterad over the ventral muscles. It gives rise to five branches, which generally extend caudo-laterad to the different parts of the corresponding segment. Branch *1* originates from the cephalic side, near the base of the main trunk. It is a very small nerve and can be detected only in well prepared specimens. The distal end of this branch unites with the transverse nerve (*tv. n.*) forming a single nerve, which extends laterad to the minute *tracheal* nerve* (*tr. n.*) Branch *2* consists of a large nerve originating from the caudal side, a few millimeters from the base of the main trunk. It extends caudo-laterad over the neighboring muscles (Fig. 1, m_1) and then turns ventrad and innervates the deep lying ventral muscles. Branch *3* arises shortly distad of branch *2*. It is a rather large nerve, passing latero-caudad over the ventral muscles. On reaching the outer border of these muscles, the nerve passes underneath a few muscle-fibers (Fig. 1, m_2 and Fig. 8, v_1 m_1) of the same

* Since the nerves of the *tracheal system* have not been considered in this paper, in may be necessary to state that such nerves have been observed lying closely connected with the trachea and in certain instances dividing in such a way as to supply each tracheal branch. The tracheal nerves are connected with both the central and the sympathetic systems.

group. Thus the nerve on passing to the upper portions of the body is protected and held away from the viscera. Branch *4*, like branch *3*, passes underneath the muscle-fibers of m_2, then below the larger lateral tracheal tube and innervates the lateral filament. Branch *5* consists of a small nerve which originates from the proximal part of branch *4*. It generally extends laterad, passing under the lateral muscle fibers of m_2 (Fig. 1) and extends to the lateral trachea, where it unites with the tracheal nerve described in connection with branch *1*.

In the seventh segment, branch *1* of the lateral nerve trunk may be absent. When present, it does not join the transverse nerve as is generally the case in the other segments, but terminates in the ventral diaphragm.

The ventral nerve trunk (*v*), originates from the ventral side of the ganglion and extends caudo-ventrad innervating various of the more ventral muscles. Branch *4* passes between the muscles and the body-wall and innervates the tracheal gills (Fig. 3, *op.*)

Because of its inconspicuous position this nerve has been very generally overlooked though it is probably to be found in other groups.

The First Abdominal Ganglion. Unlike the rest of the abdominal ganglia the first is situated below the ventral muscles. It may be located readily by the presence of the diagonal and transveres muscles, which pass dorsad of it (Fig. 1). The nerves of this ganglion are homologous to those of the following ganglia, although they show greater tendency to variation than the latter. Thus branches *1* and *2* may sometimes arise as a single nerve independent of the main lateral nerve. Moreover, branch *1* ramifies more freely than do its homologues of the following segments and it has not been observed to be connected with the transverse nerve, but seems to innervate certain ventral muscles.

The Eighth or Terminal Ganglion (Figs. 10, *G. 8.*) The terminal ganglion of the central nervous system has been pushed cephalad into the central portion or even to the anterior border of the seventh segment, taking the normal position of the seventh ganglion, which, also, has been forced cephalad, and is situated at the caudal border of the sixth segment. The seventh and eighth ganglia are united by two very short connectives, which are generally not longer than the diameter of the last ganglion.

From the large size of the terminal ganglion and because of the numerous nerves arising therefrom, it is evident that it is produced by the fusion of two or more ganglia. Oudemans '87 determined in Machilis maritima Latr. that the last abdominal ganglion originated by the fusion of the last three ganglia. On its dorsal side there remained parts of two transverse nerves, which indicated the boundaries of the original ganglia. Such rudiments of the transverse nerves have not been found in the terminal ganglion of the Corydalis larva. Influenced, however, by the fact that there are four pairs of nerves arising from this ganglion, we may conclude that these correspond to two lateral and two ventral pairs of nerves of two abdominal ganglia. Although it may be possible to homologize some of these nerves with those of previous ganglia, it cannot be considered conclusive that the last ganglion is produced by the fusion of but two ganglia, since it may be possible that the nerves corresponding to a third have disappeared. An investigation of the embryological condition would be the only way to settle this problem.

Notwithstanding the cephalic displacement of the eighth ganglion, all of its nerves innervate the eighth and terminal segments. As stated above, there are four pairs of nerves arising from this ganglion (Fig. 10 *a*, *b*, *c*, *d*). The first of these originates from the lateral border of the ganglion and runs caudo-laterad to various parts of the eighth segment. The branches of this nerve can readily be homologized with the lateral nerve of previous ganglia. Branch *1*, as in some of the previous ganglia, is in this case absent altogether. Branch *2* passes over the large ventral muscle bundle m_3 in the eighth segment and innervates the ventral muscles. Branch *3* supplies the dorsal parts of the segment; branch *4* enters the lateral filament; branch *5* joins the tracheal nerve.

Nerve *b* is homologous with nerve *v* of the previous segment. It originates from the mid-ventral portion of the ganglion and extends caudad, passing underneath the ventral muscles (m_3), then turning laterad, innervating approximately the same regions as the ventral nerve of previous ganglia.

Very probably nerves *c* and *d* are homologous to the lateral (*l*) and ventral (*v*) nerve trunks of ganglion *7*. Nerve *c* has three prominent branches, the first of which forks giving off one nerve to the lateral filament and one to the proleg. Branch *2* enters the proleg. Branch *3* innervates the reproductive organs as

shown in Fig. 10, passing through the lateral borders of the seminal vesicle.

THE INTESTINAL NERVE* (Figs. 9 and 10, *in. n*). The intestinal nerves consist of a pair of long, thread-like nerves, which arise from the proximal ends of nerve *c* of the terminal ganglion. They extend cephalad to the second abdominal segment, where they are attached to the sides of the small intestine, shortly caudal of the origin of the Malpighian tubes.

Each proximal portion of these nerves gives rise to five caudad-projecting branches, four of which innervate the hind intestine. The first branch arises from the very base of the intestinal nerve and lies dorsad of nerve *c*. It divides into three subbranches before reaching the hind intestine. Branches *2*, *3*, and *4* do not ramify until reaching the intestine. Branch *5* is comparatively small and, unlike the four previous ones, does not reach the intestine, but is attached to a mass of adipose tissue (*ad*).

The intestinal nerves represent the first or basal branch of the lateral nerve, but in distribution they differ radically from that of this branch in preceding segments. It is probable that the suppression of the respiratory nerve, originally occurring between the ganglia represented, and the in-pushing of the proctodaeum are sufficient to account for these modifications, great as they appear.

THE SYMPATHETIC NERVOUS SYSTEM.

The sympathetic system is divided into the UPPER SYMPATHETIC SYSTEM, lying above the alimentary canal, and the LOWER SYMPATHETIC SYSTEM, lying below it.

The nerves and ganglia of this system are very minute and constitute a supplementary system intimately connected with the central system. Most of the nerves are susceptible to methylene-blue and can best be studied in specimens prepared with this stain.

The UPPER SYMPATHETIC SYSTEM is confined to the anterior dorsal portion of the alimentary canal and most particularly to the pharynx and oesophagus within the head. It can be divided into an UNPAIRED MEDIAN and a PAIRED LATERAL SYSTEM.

THE UNPAIRED MEDIAN, STOMOGASTRIC, or, as it is more generally termed, the VAGUS SYSTEM, consists of the following parts:

* Comstock & Kellogg, '04, p. 49.

THE ARCHED NERVE (Fig. 4 and 7, *ar*). The arched nerves connect the vagus system with the central system. They arise in connection with the clypeo-labral nerves, one from each upper basal portion of the crus cerebri, and bend mesad so as to meet in the frontal ganglion.

THE FRONTAL GANGLION (*fg*). This ganglion consists of a very minute nerve center, situated a short distance in front of the supraoesophageal ganglia, with which it is connected by an exceedingly fine nerve strand. (Fig. 7, *i*).

THE FRONTAL NERVE (Figs. 4, 7, *f*). The frontal nerve arises from the anterior border of the frontal ganglion and extends cephalad into the clypeus, where it bifurcates.

THE PHARYNGEAL NERVE (Figs. 4, 7, *pn*). From either side of the frontal ganglion there arises a small nerve, undescribed by former workers. It extends latero-ventrad, to the lower portions of the pharynx. The term *pharyngeal* may be applied to this nerve.

THE RECURRENT NERVE* (Figs. 4, 7, *r*.). The recurrent nerve consists of a single median nerve-cord arising from the caudal border of the frontal ganglion. It extends back passing under the supraoesophageal ganglia, and between the aorta and oesophagus, to terminate in the vagus ganglion (*v*).

THE VAGUS GANGLION (Figs. 4, 7, *u*.) This is a minute elongated ganglion, not much wider than the diameter of the recurrent nerve. It is situated 3-4 millimeters caudad of the supraoesophageal ganglion, between the aorta and the oesophagus, and constitutes the termination of the recurrent nerve.

THE STOMOGASTRIC NERVES (Figs. 4 and 7, *st*.) consist of two parallel cords, arising from the caudal border of the vagus ganglion. At the point of emergence from underneath the aorta, they diverge, passing over to either side of the oesophagus, whence they continue caudad, innervating the alimentary canal and terminating in the neighborhood of the mid-intestine.

THE LATERAL OR PAIRED SYMPATHETIC SYSTEM (Figs. 4 and 7). This system is characterized by a pair of small ganglia (*lg*), situated one on either side of the oesophagus and slightly caudad of the pharyngeal constriction. The nerves are quite minute and are confined to the dorsal and lateral portions of the anterior region of the oesophagus.

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* According to Berlese '07, p. 597, the recurrent nerve is typically double and appears as a single nerve through coalescence.

There seems to be no connection between the two lateral ganglia, nor are these connected with the vagus system as is generally the rule in insects. They are united to the central nervous system by the nerves *u* and *m*. Nerves *u* are attached to the ventral borders of the two halves of the brain and run caudad one on either side of the recurrent nerve until emerging from underneath the aorta to which they are closely joined. At this point, the nerve *u* increases in thickness (*z*) and curving gradually latero-ventrad, finally enters the cephalic portions of the ganglion. Nerve *m* is attached to the ventro-lateral border of the brain and extends caudad along the dorso-lateral portion of the oesophagus. Near its attachment to the brain, it gives off a lateral branch (*x*), which appears like a separate nerve of the brain. Caudad, nerve *m* gives off three branches, the first two of which join the enlarged transverse portion of nerve *u* (labeled *z*). The third branch joins nerve *p* of the same system. Nerve *p*, extending cephalad as a continuation of nerve *z*, innervates the lateral parts of the pharynx, caudad of the crura cerebri. Nerve *q* arises from the anterior lateral part of the ganglion (*lg*) and extends cephalad, passing between the mandibular muscles and the oesophagus, and underneath the optic, antennal and mandibular nerves to the lateral portions of the mouth. Nerve *s* projects caudad from the lateral ganglion, passing for some distance parallel to the stomogastric nerves. It gives off numerous small branches to the sides of the oesophagus.

The Ventral Sympathetic or Superadded System (Figs. 1, 2, 3, 5, and 10).

The ventral sympathetic system consists of a minute MEDIAN NERVE (*mn.*) extending caudad from each of the first eleven ventral ganglia. As a rule, the median nerve gives rise to a pair of lateral branches, the TRANSVERSE or RESPIRATORY NERVES (*tv. n.*) which extend laterad over of the connectives and nerves of the central system.

The median nerve arising from the suboesophageal ganglion is comparatively short. In a few instances it has been found wanting altogether, so that the transverse nerves arise directly from the ganglion. These transverse nerves are united with the first pair of nerves of the connectives (n_1c).

In the thorax, the median nerves are short and give rise to relatively very large transverse nerves. These extend caudo-laterad over the ventral muscles and unite with the tracheal

nerves (Fig. 2, *tr*. n.) Each transverse nerve of the third thoracic ganglion gives off a small mesal branch, which innervates the small transverse muscles of this region. Before reaching the tracheal nerve, the last mentioned transverse nerve receives branch *5* of the lateral nerve trunk of the first abdominal ganglion.

As a rule, the median nerve of each abdominal segment extends caudad to the anterior border of the following ganglion (Fig. 3). Here it terminates in an enlargement, which may be the GANGLION OF THE MEDIAN NERVE* (*mg*).

The transverse nerves are two in number for each median nerve. Each extends laterad receiving branch *1* of the lateral nerve and forming with it a single nerve, which connects with the tracheal nerve.

Exceptions to the above typical condition occur in the first and seventh abdominal segments. The median nerve of the former does not give rise to any transverse nerves (Fig. 1) and in the latter the median nerve does not reach the following ganglion but terminates in the two transverse nerves (Fig. 10).

As stated in connection with the mandibular nerve, a minute ganglion is to be found at the base of the mandible, (Fig. 6), forming a part of the sympathetic system. The main nerve *4* enters the mandible and gives off four branches. The caudal termination of nerve *4* has not been traced. Nerves *6* and *7* are also part of this system. Branch *2* connects the ganglion with the central system.

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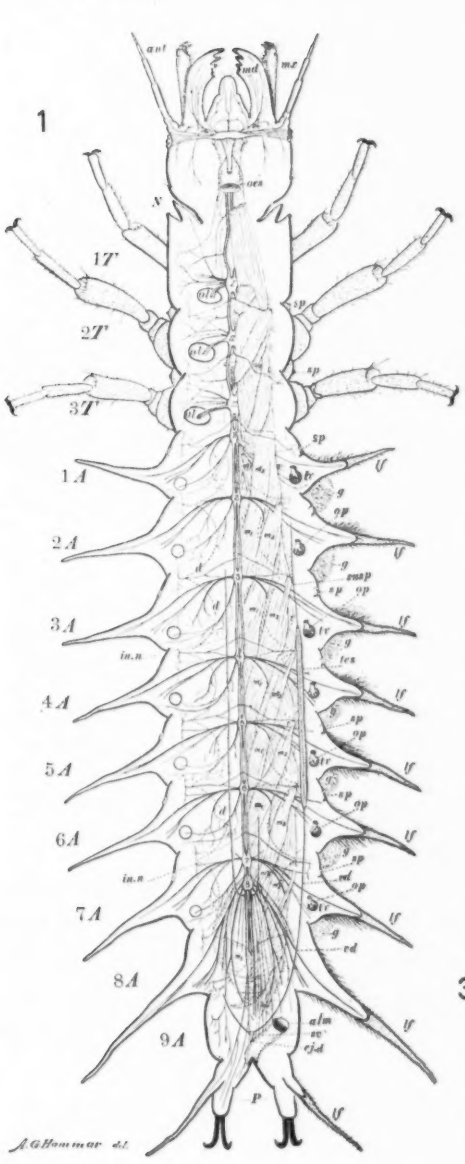
EXPLANATION OF PLATES.

FIG. 1. Dorsal aspect of the larva, showing the entire nervous system. The ventral longitudinal muscles have been represented on the right side to illustrate their relation to the nerves.

1A, 2A, 3A, etc., abdominal segments.
1T, 2T, 3T. first, second and third thoracic segments.
I, II, III. first, second and third thoracic ganglia.
1-8. first to eight abdominal ganglia.
alm. alimentary canal.
ant. antenna.
d, d, d. outline of the ventral diaphragm.
ej. d. ejaculatory duct.
g, g. tracheal gills.
in. n. intestinal nerve.
lf, lf. lateral filaments of the abdominal segments.
m_1, m_2. upper-great-ventral-recti-muscles.
m_3. large bundle of muscles in the ninth abdominal segment.
md. mandible.
mx. maxilla.
N. neck.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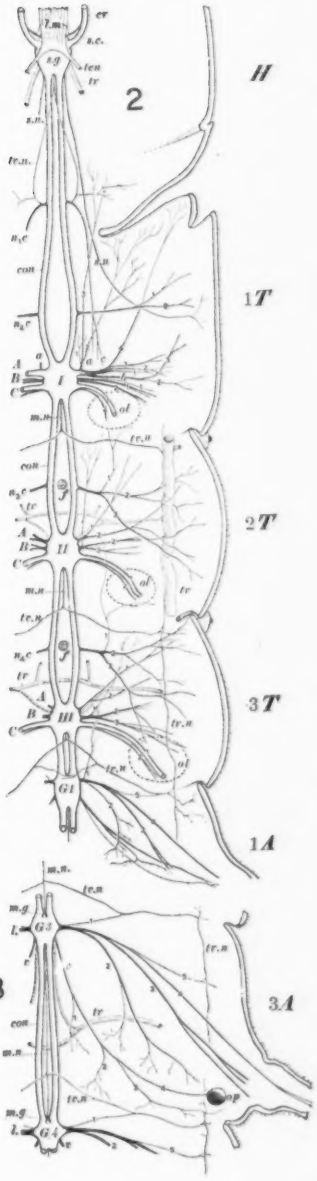
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oes. oesophagus.
ol. opening to the leg.
om. oblique muscles of the first abdominal segment.
op. opening to the tracheal gills.
P. prolegs.
sp. spiracle.
susp. suspensory ligament of the testis.
s. v. seminal vesicle.
tes. testes.
tr. tracheae supplying the gills.
vd. vas deferens.

FIG. 2. Dorsal view of the five anterior ventral ganglia. Lettering as in Figs. 1 and 3.

FIG. 3. Third abdominal segment.
1A, 3A. first and third abdominal segments.
1T, 2T, 3T. first, second and third thoracic segments.
I, II, III. first, second and third thoracic ganglia.
A. B. L. nerve trunks of the thoracic ganglia.
a, b, c. branches of nerve *A* of ganglia *I. 1, 2, 3, 4**, are sub-branches to same nerve.
con. connective.
c. r. crura cerebri.
f. furcae.
G1, G3, G4. first, third and fourth abdominal ganglia.
H. head.
l. lateral nerve-trunk of abdominal ganglia.
lm. labial muscles.
m. g. minute ganglion of the median nerve.
m. n. median nerve.
n_1c, n_2c, n_3c, n_4c. first to fourth nerve of the connectives.
ol. opening to the leg.
op. opening to the tracheal gills.
s. c. suboesophageal commissure.
s. g. suboesophageal ganglion.
sn. salivary nerve.
ten. tendon of the labial muscles.
tr. tracheae.
tr. n. tracheal nerve.
tv. n. transverse nerve.
v. ventral nerve-trunk of abdominal ganglia.

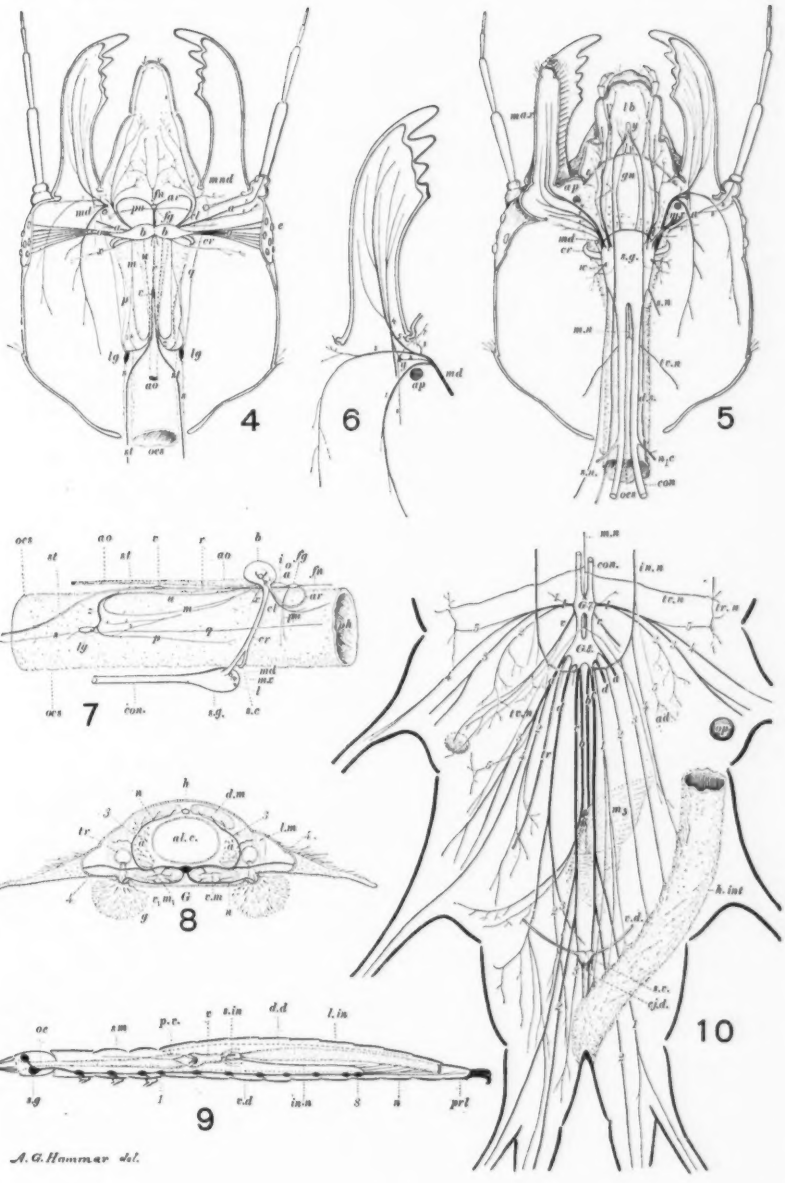
FIG. 4. Dorsal view of the head. Lettering as in Fig. 7.

FIG. 5. Ventral view of the head.

FIG. 6. The mandibular nerve.

FIG. 7. Lateral view of the nerves of the head.
a. antennal nerve.
ao. aorta.
ap. apodeme.
ar. arched nerve.
b, b. brain or supraoesophageal ganglia.
cl. clypeo-labral nerve.
con. connective.
cr. crura cerebri.
d. s. salivary duct.
e, e. simple eyes.

* Other numbers in these and following figures designate main branches of the different nerve trunks.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fg. frontal ganglion.
fn. frontal nerve.
g. ganglion of the mandibular nerves.
gn. gustatory nerve.
i. nerve connecting the frontal ganglion with the brain.
l. labial nerve.
lb. labium.
lg. lateral ganglion.
max. maxilla.
md. mandibular nerve.
m. n. median nerve.
mnd. mandible.
m, p, q, s, u, z. nerves of the lateral sympathetic system.
mx. maxillary nerve.
n_1c. first nerve of the connective.
o. optic nerve.
oes. oesophagus.
ph. pharynx.
pn. pharyngeal nerve.
r. recurrent nerve.
s. c. suboesophageal commissure.
s, g. suboesophageal ganglion.
s. n. salivary nerve.
st. stomogastric nerve.
t. trachea in the labium.
tv. n. transverse nerve.
v. vagus ganglion.
w. nerve of the suboesophageal ganglion.
x. nerve of the brain.
y. opening of the salivary ducts.

FIG. 8. Section through an abdominal segment, showing the distribution of the nerves.
3, 4. branches of the lateral nerve.
a. adipose tissue.
alc. alimentary canal.
d. m. dorsal muscles.
G. abdominal ganglion.
g. gills.
h. heart.
l. m. lateral muscles.
n, n. nerves.
tr. trachea.
v. m. ventral muscles.
v_1m_1. fibers of the ventral muscles passing over the nerves (compare with Fig. 1, m_2).

FIG. 9. Lateral view of the larva showing the attachment of the intestinal nerve. (Compare with Figs. 1 and 10).
1-8. first to eighth abdominal ganglia.
d. d. dorsal diaphragm.
in. n. intestinal nerve.
l. in. large intestine.
n. nerve of the terminal ganglion.
oe. oesophagus.
prl. proleg.
p. v. proventriculus.
s. g. suboesophageal ganglion.
s. in. small intestine.
sm. suspensory muscles of the alimentary canal.
v. ventricle.
v. d. ventral diaphragm.

FIG. 10. Terminal portion of the nervous system of the abdomen.
a, b, c, d. nerve-trunks of the terminal ganglion.
ad. adipose tissue.
con. connective.
ej. d. ejaculatory duct.
G7, G8. seventh and eighth abdominal ganglia.
h. int. hind intestine.
in. n. intestinal nerve.
l. lateral nerve-trunk.
m. n. median nerve.
m_3. bundle of muscles in the eighth abdominal segment.
op. opening to the tracheal gills.
s. v. seminal vesicle.
tr. trachea.
tr. n. tracheal nerve.
tv. n. transverse nerve.
v. ventral nerve-trunk.
v. d. vas deferens.

A CASE OF GREGARIOUS SLEEPING HABITS AMONG ACULEATE HYMENOPTERA.

By J. CHESTER BRADLEY.

Mr. Banks* has summarized what was recorded up to the time he wrote concerning the sleeping habits of Hymenoptera. Briefly, this consisted of several observations of usually solitary aculeates either sleeping in flowers or clinging to twigs. Belfrage has observed Scolia lecontei "during the night and chilly weather in clusters, closely attached to the stems of grass and plants."

Mr. Banks' observations were made in a small patch of timothy, orchard grass and wild onion. Here he found specimens of three species of Ammophila, of two bees, and of Myzine sexcincta sleeping, but always only *one* individual on the same stem of grass. Night after night they would appear between seven and eight, and leave before five the next morning. Gradually they became less numerous. Near the patch was a field of recently cut rye, where he surmises they may previously have rested, and also a garden and bean patch.

Mr. Schwarz† records observing in southwestern Texas within a short space, four dead shrubs of Celtis pallida which harbored from fifty to seventy specimens of two species of bees asleep, and near at hand other shrubs with a smaller number of specimens.

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* Journ. N. Y. Ent. Soc. Vol. X, p. 209.
† Proc. Entom. Soc. Wash., IV, p. 24.

Always in company with the bees was a Sphegid (Coloptera wrightii) which at the time of his observations, seven-thirty on cloudy mornings, was walking slowly up and down the twigs over the bodies of the sleeping bees.

Mr. Brues‡ records several very interesting additional observations. Along the shore of Lake Michigan he found one evening both sexes of Prionony x atrata sleeping in large numbers on the thicker parts of a plant of sweet clover. In McHenry County, Ill., also on sweet clover he and Mr. Melander noticed the following species commingled in sleep: Scolia bicincta, Nysson plagiatus; Tachytes sp., and some other smaller forms. Epeolus was predominating. He has frequently observed males of Scolia lecontei resting on an umbelliferous plant in Texas. In southern Illinois he noticed males of Myzine sexcincta in abundance sleeping on a small dried plant. Mr. Brues further questions why certain plants are regularly chosen by certain species. In some cases, as that of Prionony x atrata it may have been odor, although the species does not frequent sweet clover much during the day. Scolia lecontei he shows is afforded a certain concealment by harmonizing, in the head downward position which they assume, with the plants, although they would be much more perfectly concealed on certain bright flowers which they leave alone.

On the second of June last summer I was driving in the Mt. Diablo Range along the Arroya de los Gatos near where it opens out into the extremely hot and dry Kettleman plains in the southwestern part of the San Joaquin Valley in Fresno County, California, when slightly before dusk my attention was called to a bunch of dark objects attached to a dried stem of wild oats. Upon observation they proved to be black wasps asleep, (Prionony x atrata). Looking farther I observed another and still another such group, and within the next hour, or until it became too dark to see them, I observed scores, almost hundreds of these bunches of resting wasps, sometimes on wild oats, sometimes on other plants. Each group contained from one or two to a couple of dozen individuals, and I was often able to break them off and place them in a jar before they became considerably aroused. In all I captured 490 odd individuals before total dark, about an hour's time.

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‡ Journ. N. Y. Ent. Soc., XI, p. 228.

No less than seven species of aculeate Hymenoptera were represented in large numbers, belonging to three different families, four sub-families and five genera, *and each species so far as observed was always grouped separately.* Though a group of one species were in close juxtaposition to that of another on a neighboring stem there was no intermingling of individuals.

Returning on a subsequent evening a week later (but perhaps not finding precisely the same place at a favorable time), I found the bunches of wasps less abundant, but still present, and found a few groups of an eighth species.

The species found on the first night were Chlorion (Priononyx) atratum; C. (Priononyx) bivefoleatum; two species of Sphex (formerly Ammophila-synonym of Sphex); Monedula emarginata; Steniola duplicata, and Stizus unicinctus, the last two being especially common. On the second visit the above were found, and one additional species, Sphecius fervidus Cr. On both occasions, there were a few individuals of one or two other species, notably bees, Bombus, sp., Halictus farinosus and Melissodes agilis, etc.

I am indebted to Prof. Fernald for the identification of the Sphegidæ and to Mr. H. L. Viereck for that of the others, excepting Sphecius fervidus, which is my own determination.

The vegetation in that part of the San Joaquin Valley had already for over a month been scorched dry and brown by the intense sun-heat and absence of rain. Along one side of the road in the canon the vegetation had been freshly burned off by extensive prairie fires. Along the other side was a field of recently cut grain with a narrow standing strip along the road in which were situated the groups of wasps, not only on the oats, but on one or two other dried plants. We found them at intervals for perhaps a mile or more and then it became too dark to see further. Not everywhere along the road were the conditions as above described, in some cases the bunches occuring in a tangled growth of dried weeds.

On subsequent evenings I hunted in vain for sleeping wasps in the sage brush and fox-tail grass on the plains, twelve miles distant. No trace of the wasps was to be found.

The fact that the "hostelry" described by Mr. Banks was also bordered by a field of recently cut grain may not be a mere coincidence. It is quite possible that normally these wasps are scattered through such fields when sleeping at night, and that by the

cutting of the grain are driven into the outlying standing patches. There certainly was no protection received from their gregarious sleeping, since the groups of wasps were very conspicuous objects in the failing light.

Perhaps it would require considerable knowledge of wasp psychology to be able to answer, first, why they congregate at all, instead of each sleeping on whatever stem of oats happens to be convenient, and second, why when thus congregating they ignore the similarly situated groups of other, even close related species, and choose only those of their own fellows. The wide range of the species implicated would seem to indicate that the habit is either a fundamental one, or else a general response to some peculiar environmental condition.

Entomological Laboratory, The University of California, August 1, 1907.

NOTES ON THE LIFE HISTORY OF THE LEAFY DIMORPH OF THE BOX-ELDER APHID, CHAITOPHORUS NEGUNDINIS THOS.*

By J. J. Davis, Office of the State Entomologist, Urbana, Ill.

My attention was first called to this curious dimorph by Mr. J. T. Monell, who found it at St. Louis, June 21, 1907, and had received it from Oestlund as early as 1889.

The life history of the dimorph I have found to be essentially like that of the dimorph of the European C. testudinatus Thorn., as described by Kessler.

In central Illinois the viviparous females begin to produce the dimorphs about June 1, and the latter, after crawling over the leaves for a short time, attach themselves to the veins of either surface of the leaf. There they remain in a dormant condition for two or three months. By the last of June or the first of July the parent females begin to disappear, and soon only stragglers can be found. In the latter part of August the dimorphs revive, molt several times, and become viviparous females. Subsequent generations are oviparous, and lay the eggs which are to carry the species over the winter.

The dimorphs are inconspicuous; they appear as minute flat scales lying close against the leaf, and having the same green color as the leaf.

The dimorph of C. negundinis is indistinguishable from that of C. testudinatus as described and figured by Kessler.

Here follow some of the details of the life history. Looking for this dimorphic aphid June 12, 1907, I found it common on both the upper and the lower surfaces of the leaves of box-elder at Urbana, Ill. At that time the winged and wingless normal forms were also abundant. The following figures show the abundance of the dimorph. June 15 the total number on the upper surfaces of twenty leaves was 1988, and on the lower surfaces, 2088—a total of 4076 individuals on the twenty leaves, or an average of 203+ to each leaf. July 19, on ten leaves which were only slightly infested and in a shaded situation, the total number of individuals on the upper surfaces was 214, while on the lower surfaces there were but 23 — a ratio of 9 on the upper to 1 on the lower. After July 1 the normal forms began to disappear, and by July 19 they occurred only occasionally. Between that date and August 5 none of the normal forms were noticed, although careful searches were made for them. August 5, however, I found four young of the normal form and from one of these I obtained young. She began to bear young August 13, and bore in all 73 young, of which 27 were dimorphs and the remaining 46 normal forms. Owing to my absence I was unable to trace these to the sexual forms. August 20 I found the aphids becoming suddenly abundant on the box-elder leaves. These aphids had a decidedly reddish tinge, and were, I infer, dimorphs which had molted; since a dimorph that molted August 27 later developed into a reddish normal form. Both out-of-doors and in the insectary I have noticed the dimorphs in the act of molting.

It is probable that the fully developed dimorphs are the mothers of the sexual forms, although I have no positive evidence of this. I infer, also, that the mothers of the dimorphs may belong to any of the earlier generations.

The dimorph is capable of locomotion. In a chimney cage containing a small box-elder plant I placed pieces of leaves bearing dimorphs. As soon as the pieces of leaves began to dry up the dimorphs moved from them to the fresh leaves. In another instance the dimorphs, when transferred directly to fresh leaves with a brush, attached themselves readily to these.

I have found this dimorphic form in many localities in northern and southern Illinois, but most abundantly at Urbana.

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* Read at the Chicago meeting, December 30th, 1907.

Coccinellid and chrysopid larvae have often been observed feeding on the dimorph.

The first paper on the American dimorph is an article by Mr. L. C. Bragg in Entomological News for December, 1907. His statement that it does not molt or reproduce is incorrect. In comparing the European dimorph with the American dimorph he states that the former has fourteen leaf-like appendages on the abdomen and the latter twenty-two; I find, however, that both the American and the European dimorphs have twenty-two flabella on the margin of the abdomen. Mr. Bragg mentions the maple-aphis (Chaitophorus aceris) as being the species that produces the European leafy dimorph. This was supposed to be the case until Kessler proved that they were borne by Chaitophorus testudinatus and not by C. aceris. He found that C. aceris produces dimorphs, to be sure, but dimorphs without leafy appendages.

Professor Oestlund, in a paper on this dimorph in Entomological News for March, 1908, summarizes the more important literature on the European dimorph. He refers to the species as occurring on "maples," but informs me by letter that he used this name for Acer negundo, the common box-elder. He uses the name testudinatus instead of negundinis for this species; but it appears from Kessler's paper that the adults of testudinatus are quite different from those of negundinis—so different that we can scarcely regard the two species as one.

THE GENUS CORIZUS.

With a Review of the North and Middle American Species.

By J. C. Hambleton.

INTRODUCTION AND ACKNOWLEDGMENTS.

The writer wishes to express his sincere thanks to those who have contributed to the success of this work by allowing him the use of their collections. Among these should be mentioned first Prof. Herbert Osborn who allowed the use of his private collection as well as that of the Ohio State University. Prof. Comstock sent the collection belonging to Cornell University, and Mr. Heidemann of the National Museum sent his private collection of several hundred specimens. The collection belonging to the Colorado Agricultural College was also at the writer's disposal. Without this extensive material, it would have been impossible to arrive at many definite conclusions concerning the genus.

The first insect of this genus to be described was crassicornis. Linneus in 1758 gave it a brief description and included it in his large genus Cimex. Fabricius, in 1794, described two more species, sidae and hyalinus, under the generic name of Lygaeus, but later, in 1803, he changed them to the genus Coreus. In 1814 Fallen created the genus Corizus and gave it the following limitations: "Corpus oblongum; antennarum basali brevi; ultimo subclavato; thorace planiusculo; hemelytris oblique truncatis; membrana longitudinaliter multinervosa." In 1828, in his Hemiptera Sueciae, pages 41 to 45, he includes six species, not all of which, however, have remained in this genus. The only American species included here is crassicornis, a very common European insect.

Signoret in 1859, in the Ann. Soc. Ent. Fr., published a monograph of the genus. This is a notable work and has served as the basis of nearly all the work that has been done on the genus since his time. He recognized the practical impossibility of separating the genus into natural groups, or subgenera. He includes fifty-four species from all parts of the world, and describes many new American species, some of which have not withstood the test of time, probably because his material was not abundant enough for him to understand their variations.

Stal, in 1870, in his Enumeratio Hemipterorum, Vol. 1, divides the genus into three sub-genera as follows: Liorhyssus, Niesthrea and Arhyssus, and follows this up in the third volume of the same work three years later on pages 97 and 98 by abandoning the genus Corizus entirely and creating from it three new genera, Liorhyssus, Peliochrous and Stictopleurus. Fieber, in 1861, had also made three genera of this genus, namely: Rhopalus, Corizus and Brachycarenus.

Lethierry and Severin in 1893 have abandoned these subdivisions and retained the genera Corizus and Maccevethus.

DESCRIPTION OF THE GENUS.

Body, narrowly ovate or oblong-ovate. Head short, conically produced in front of the eyes and narrowing abruptly behind. Rostrum reaching the posterior coxae. Antennae slender with first and last segments thickened, the former short, scarcely reaching or but slightly passing the apex of the head. Pronotum trapezoid shaped, crossed near its anterior margin by the transverse suture which is more or less plainly marked, and is interrupted at its middle by the median line. Scutellum a little longer than wide. Membrane with numerous simple veins. Metapleura dilated posteriorly. Legs medium, unarmed, the posterior pair slightly the longest. Body pubescent and punctured.

Taken as a whole the genus is truly cosmopolitan, being found both in the temperate regions and in the tropics. It is probably more abundant in the latter but is widely distributed in the former. One species, hyalinus, has been reported from Australia and the Philippines, Europe, Asia, Africa and America. Another species, crassicornis, is circumpolar in its distribution, being found in northern and central Europe and in northern North America, and entirely across Siberia. Still other species, such as scutatus and tuberculatus, as far as known, are confined to comparatively small areas.

Little is known of their habits. They probably hibernate, in temperate regions, in the adult state and deposit their eggs in early summer when their food plants have developed sufficiently to furnish food for their young, and reach maturity in early autumn. None of the species are sufficiently numerous to be of economic importance, though under changed conditions they might easily become so.

BASIS OF SEPARATION OF SPECIES.

Many mistakes have been made in the past by placing too much confidence in color characters in the determination of species. This is very unsafe, as it would be difficult to find a genus more variable and inconstant in this respect. In this paper structural characters alone are used for this purpose. A careful study of an abundance of material has shown that these are reasonably constant. The form and position of the antenniferous tubercles and rostral lobes are excellent characters to separate some of the species. The nature of the transverse suture on the pronotum, and the form of the scutellum serve for others. The genitalia give us excellent characters for several species, and the general form of each species varies but little, though the size may vary, and in several cases is quite distinctive. There is still another character that is good in a number of cases, though it is difficult of access and hence little use has been made of it. This is the nature of the dorsal sutures between the third and fourth, and fourth and fifth segments. It is a character that seems to be quite constant though at times the middle portions of these sutures may be so obliterated that it is difficult to distinguish them.

ARTIFICIAL KEY FOR THE DETERMINATION OF SPECIES.

1. (a) Last segment of abdomen short and broad, truncate in female and rounded in male ..... **hyalinus**
   (b) Not as above ..... 2.
2. (a) Antenniferous tubercles prominent; transverse suture terminating in a loop ..... 3.
   (b) Not as above ..... 4.
3. (a) Insect large. Connexivum spotted ..... **crassicornis**
   (b) Insect small. Connexivum unspotted ..... **viridicatus**
4. (a) Scutellum broad at the tip, rounded ..... 5.
   (b) Scutellum narrow at tip and pointed ..... 6.
5. (a) Antenniferous tubercles broad, sternum not black ..... **scutatus**
   (b) Antenniferous tubercles very long, reaching almost to apex of head ..... **tuberculatus**
   (c) Sternum black ..... **indentatus**
6. (a) Connexivum unspotted ..... **lateralis**
   (b) Connexivum spotted ..... 7.
7. (a) Insect large, light colored ..... **validus**
   (b) Insect medium, dark, last segment in female pointed ..... 8.
   (c) Last segment in female not pointed ..... 9.
8. (a) Last segment very long pointed ..... **punctatus**
   (b) Last segment medium ..... **nigristernum**
9. (a) Abdomen much broader than thorax, with black transverse band ..... **sidae**
   (b) Insect small, antennae short, scutellum large ..... **parvicornis**

DESCRIPTION OF SPECIES.

Corizus hyalinus Fabricius.

Lygaeus hyalinus Fabricius, Ent. Syst., IV, p. 168 (1794).
Coreus hyalinus Fab., Syst. Rhyng., p. 201 (1803).
Corizus hyalinus Stal, Hem. Fab., I p. 68 (1868); Uhler, Geol. Bull. I, No. 5, p. 34 (1875); Obs. upon Heter. Hem. of Lower Cal., p. 237 (1895); Sum. of Hem. of Japan, Pres. to U. S. Nat. Mus. by Prof. Mitzukuri (1896); List. of Hem. Heter. of Las Vegas Etc., from Proc. U. S. Nat. Mus., XXVII, pp. 349–364 (1894); On Hem. Heter. of Grenada, W. I., pp. 180–181 (1894); Oshanin, Verzeichnis Der Palearktischen Hemiptern. I, p. 227 (1906).

An easily recognized species, with adbomen truncate in female and rounded in male. Transverse suture prominent and black, lateral borders of pronotum light. Length of female, 5.7 to 6.4 mm., width 2.3 to 2.5 mm., male, length, 5.5 to 5.8 mm., width 1.8 to 2 mm.

Head triangular, narrowing from the eyes forward. Antenniferous tubercles not prominent. Rostral lobes well marked, not thickened at extremities. Eyes prominent. First segment of antennae not reaching apex of head.

Pronotum: Transverse suture very wide and close to the anterior border. Scutellum with lateral borders almost straight and slightly elevated except at the tip, which is not excavated, and a poorly defined ridge throughout its length. Abdomen truncate in female and rounded in male; decidedly wider than the thorax especially in the female. Wings longer than the abdomen. Pubescence not abundant and punctuations small.

Color: The color of this species varies exceedingly, even in individuals taken in the same locality, though the markings are quite constant. In general, the ground color may be said to be a pale yellow, though this varies to red on one hand and to dark brown or black on the other.

Head: Transverse line across the base, a curved line backward and downward from the eyes, irregular lines between the eyes and rostral sutures, black. Antennae yellow or brown, pointed with black dots which on the upper surface are sometimes confluent, forming a black line.

Pronotum: Transverse suture, posterior angles, and punctuations except on lateral borders, black. This arrangement of color produces the lighter colored borders, which are so characteristic of this species. Scutellum same as pronotum, with the elevated ridges usually, and the apex always, of a lighter color, usually yellow.

Abdomen: Above, black with several light spots on or near the median line. Connexivum red or yellow, sometimes with a dark spot on each segment. Sixth segment black, with five yellow or reddish spots on the margin in the male, and with margin entirely yellow in the female. This margin is somewhat wider at the apex. Wings hyaline, nerves yellow or reddish. Apex of coreum usually red or brown. Entire under side yellow or reddish, except sternum, which is black.

This is a cosmospolitan, tropical and sub-tropical species, extending as far north in America as South Dakota and Iowa, and south into Mexico, Middle America and the West Indies. It is one of the most common southern European species, and is found south as far as Cape Colony in Africa, and Australia, and has been reported from the Philippines. Specimens are at hand from Colorado, Arizona, Mississippi, Mexico, Wyoming, South

Dakota, Iowa, Ohio, Bermuda and Hayti. It is reported by Uhler from Lower California, New Mexico, and Grenada, W. I. Oshanin in 1906 reports it from southern Russia, Caucasia, Turkestan, Japan and Chili. (For further references and synonomy, see Lethierry and Severin's General Catalogue.)

Corizus crassicornis Linneus.

Cimex crassicornis Linneus, Syst. Nat., 10th Ed., I, p. 448; 12th Ed., I, p. 727; Faun. Suec., p. 254.
Rhopalus punctiventris Dallas, List. II, p. 526 (1852).
Corizus novaeborecensis Sign., Ann. Soc. Ent. Fr., p. 97 (1859).
Corizus borealis Uhler, Proceed. Acad. Phila., p. 284 (1862).

A large species easily recognized by its broad vertex and spotted connexivum. Length of female, 7.5 to 8.5 mm., width 3 to 3.5 mm. Male, length 6 to 7 mm., width 2.5 to 3 mm.

Head: Vertex broad, due to the thickened rostral lobes which extend almost to the apex. Antenniferous tubercles prominent, angular, and extending well forward. First segment of antennae passing beyond the apex of the head. Eyes not so prominent as in hyalinus because of the more prominent antenniferous tubercles.

Pronotum rather sharply angled anteriorly. Transverse suture terminating at either side in a closed loop. Scutellum gently narrowing from base to near the apex, where it expands slightly, and is rounded and excavated; borders slightly raised.

Abdomen rather abruptly widened at the third and fourth segments, especially in the female. Genitalia: Dorsal plate in female broadly triangular and rounded at the apex. Ventral plate compressed laterally, posterior angles rounded. Wings little, if any, longer than the abdomen. Punctuations small and pubescence very short.

Color: Above brownish gray, sometimes nearly black. Broad stripe on first segment of antennae, spots between ocelli and compound eyes, transverse suture on pronotum, black. The scutellum is usually much darker at its base and has the small depression at its apex black. Wing nerves light with few spots.

Abdomen black with three light spots, one occupying the middle of the third, fourth and fifth segments and two on the fifth, whose posterior border is also light. These spots may vary in size and may be fused, forming an inverted V-shaped spot. The sixth has two large yellow spots, one on either side, that reach the extremity. Connexivum light with a dark spot on each segment. Under side and legs yellowish gray, the latter spotted over with black. Large irregular black blotches on inner side of posterior femurs.

The color of this species, as of others, varies greatly. The ocelli may be entirely surrounded by a black spot which reaches the thorax. The transverse suture may be brown or gray, like the rest of pronotum. The black spots on wing nerves, depression at apex of scutellum, and spots on connexivum may be light or reddish brown. In very dark individuals the head, pronotum and scutellum may be heavily spotted with irregular blotches of black, and the black spots on connexivum may extend to the underside, and there may be a few small black spots, one on the posterior border on each side of the first, second and third

segments below. In such cases the spots on the abdomen above may all but disappear, except those on the sixth segment.

Rhopalus punctiventris Dallas and Corizus novaeborecensis Sign. should undoubtedly be referred to this species. Specimens from the east and from the west have been carefully compared with European specimens kindly sent by Dr. Horvath from Hungary. They are identical in all structural characters and do not differ more in color than do individuals taken in the same locality.

This is also a cosmopolitan species. Oshanin reports it as follows: All of Europe, Canaries, Tunis, Syria, all of Russia, Caucasia, Turkestan, Siberia and Japan. Uhler in various papers reports it from Colorado, Arizona, California, Washington, British America, Walrussia, Canada, Massachusetts, Pennsylvania, New York, Mackenzie River, Yukon, Saskatchewan and Lower California. Specimens are at hand from Washington, Oregon, Utah, British Columbia, California, Wyoming, South Dakota, Ohio, New York, and New Hampshire.

Corizus viridicatus Uhler.

Corizus viridicatus Uhler, Hayden's Survey of Montana, IV. Zool. and Bot., p. 404 (1872).
Corizus hyalinus Uhler, Geolog. Bull. II, No. 5 (1875), pp. 34 and 35.

A slender species, often greenish in color with the black spot on sixth segment quite prominent. Length of female, 5.5 to 6 mm., width 2 to 2.5 mm. Male, length 5 to 5.5 mm., width 1.8 to 2 mm.

The head pronotum and scutellum of this species closely resemble those of its near relative, crassicornis. They are, however, smaller, and the scutellum has its narrowest portion a little farther from the apex. The abdomen is but little wider than the thorax, and hence the sides are very nearly parallel.

Genitalia: Dorsal plate of female broadly rounded; ventral plate compressed laterally, uniform in width, posterior angles but little rounded. Dorsal plate of male broadly rounded; ventral plate much narrower at its middle point, and angles rounded. Wings a little longer than the abdomen, and opaque, thus hiding the abdominal picture except the anal spot. Pubescence soft and punctuations small.

Color: Light gray, often tinged with green, both above and below. This color, while predominant in the species, is not universal. Occasionally a specimen may be found with the thorax above, all black, except the scutellum, and the body below a reddish yellow. A broad stripe on basal segment of antennae, ocellar tubercles and a line between them and the eyes, black. Transverse suture and disk of abdomen usually black. Two broad stripes on last segment of abdomen and three spots about the middle of the disk, light. It is not uncommon to find specimens with the light color predominating on the disk, and all color may disappear except the spot on last segment.

This species was described by Uhler in 1872, but later, in 1875, he abandoned it, having come to the conclusion that it was but a variety of hyalinus. It now seems best to revive it as it certainly

is not a variety of hyalinus, but is closely related to crassicornis, from which it differs enough, however, to give it good specific rank. It seems to be confined to the west. Specimens are at hand from Colorado, Utah, California, Wyoming, Nebraska, and Assiniboine, B. A.

Corizus scutatus Stal.

Rhopalus scutatus Stal., Freg. Eug. resa. Inst., p. 239 (1859).
Corizus jactatus Signoret, Ann. Soc. Ent. Fr. p. 81 (1859).

Female, length 8 to 9 mm., width 3 to 4 mm. Male, 7.5 to 8 mm., width 3 to 3.5 mm.

Head: Antenniferous tubercles broad but not long. Rostral lobes clearly marked, narrow and not reaching the apex of the head. The whole upper surface of the head is rough and tubercular. First segment of antennae just reaches the apex of head.

Pronotum: Transverse suture on a tubercular ridge which reaches quite to the borders of pronotum. Scutellum broad and rounded at the apex which is excavated.

Abdomen prominently widened at third and fourth segments, especially in the female. Genitalia: Dorsal plate in the female broadly triangular and gently rounded at the apex. Ventral plate widest at its middle and extending backward almost as far as does the dorsal plate. In the male the middle part of ventral plate is very narrow and the posterior angles rounded. Wings about as long as the abdomen. Punctuations not prominent. The whole insect is covered with a rather thick growth of short hair.

Color: Dull reddish brown above and tinged with yellow below. The median line on pronotum is usually lighter in shade and extends to the depression on the scutellum. In very dark specimens the apex of head and first three segments of antennae are nearly black, and a black line is found between the eye and ocellus. The scutellum may also be very dark except median line and borders. In very light specimens the color is uniform throughout the whole upper surface. Disk of abdomen black, with usually two small yellow spots on anterior borders of second, fifth and sixth segments, and another in the middle of the fourth. The sixth has two yellow stripes, one on either border, which sometimes fuse with the spots. The connexivum is light with a large brownish or reddish spot on each segment. This color sometimes approaches that of the connexivum and they are then almost invisible. Sometimes there is a line on each side of the abdomen below, dark reddish brown. Legs with a few small black points.

This species is not widely distributed, being, so far as known, confined to the western United States. Specimens are at hand from Oregon, Utah, Wyoming and California.

Corizus indentatus n. sp.

Somewhat resembling scutatus but smaller and more hairy. Length of female, 4.5 to 6 mm., width 2 to 3 mm. Male, length 4.5 to 5 mm., width 2 to 2.5 mm.

Head: Antenniferous tubercles small but rather sharp, very close to the eyes. Rostral lobes short and obscure. First segment of antennae reaches a little beyond the apex of the head. Upper surface rough and tubercular.

Pronotum tubercular, especially in the region of the transverse suture which is often difficult to trace on this account. This suture forms a rather deep depression on either side of the median line. Scutellum rather broad and rounded at apex, with borders slightly raised near the end which is not excavated.

Abdomen but little wider than pronotum. Genitalia pretty much as in scutatus, though the entire sixth segment of the female is relatively shorter, and the ventral plate in the male is not so narrow at its middle point. Wings a little longer than abdomen. Whole insect covered with rather dense hair.

Color, reddish brown with no distinctive markings. The pronotum is sometimes irregularly blotched with black, and its posterior border, with the base of the scutellum may be dark or almost black. Beneath the color is lighter, often tinged with yellow and minutely spotted with red. Sternum black, and often a dark brown line on either side of abdomen below, near the borders. The first and second segments of disk of abdomen are black, and the remaining four may be black also, but usually are brown. The third has two small spots on anterior margin and the fourth a rather large oval spot at its center; the fifth has two smaller oblique spots at its anterior margin and several small round spots below these; the sixth with the conventional yellow lateral stripes and the long black spot between them. Connexivum alternating dark and light, sometimes one predominating and at others the other. The dark portions are frequently ornamented with one or more small round spots of a lighter color. The legs are reddish yellow spotted with brown. Wing veins with a few brown spots. Membrane with a slight reddish tinge.

This also is a western species, and was recognized as new by Uhler who proposed for it the name indentatus, but never published a description. Specimens are at hand from British Columbia, Washington, Oregon, California, Wyoming and Colorado.

Corizus tuberculatus n. sp.

Medium in size, with antenniferous tubercles abnormally long. Rather yellowish in color. Length of female, 6 mm., width 2.7 mm.

Head: Antenniferous tubercles very long, reaching almost to the apex of the head and diverging widely. Rostral lobes small but distinct. First segment of antennae passing the apex of head.

Pronotum: Transverse suture bordered anteriorly by a tubercular ridge. Anterior angles not prominent. Scutellum broad at the apex, rounded and excavated.

Abdomen not much wider than thorax and sides nearly parallel. Genitalia of female very similar to scutatus. Wings equal to abdomen in length. Pubescence slight. Punctuations prominent.

Color: Reddish yellow, a little darker above than below. Head a little more tinged with red. Eyes dark. Small black spots between ocelli and eyes. Posterior angles of pronotum darker. Scutellum light, unspotted. Disk of abdomen black with a small elliptical spot at its center and six smaller ones surrounding, and at some distance from it. Several other very small round spots are scattered over the surface. The posterior border of the fifth and all of the sixth segments light. The latter has a darker portion at its middle. This spot has the same form as the black stripe that is so common in this genus but is not black as is usually the case. Beneath, the insect is unspotted except the sternum which is black.

This insect is described from two females taken by Mr. Heidemann at Pullman, Washington.

Corizus lateralis Say.

Coreus lateralis Say, Jour. Acad. Phila., IV, p. 320 (1825); Complete Writings, II, p. 245.

Rhopalus punctipennis Dallas, List., II, p. 526 (1852).

Corizus lateralis Signoret, Ann. Soc. Ent. Fr. p. 97 (1859); Uhler, Hayden's Survey Mont., IV, Zool. and Bot., p. 404; Bull. Geol. and Geog. Survey, II, p. 301, and III, p. 408; Proc. Boston Soc. Nat. Hist. XIX, p. 386. Distant, Biol. Cent. Amer., pl. XVI, fig. 9 and 10 (1881).

This is a light colored species, red and yellow predominating. Eyes prominent and apex of head sharp pointed. Length of female, 5.5 to 6 mm., width 2.5 to 3 mm. Male, length 5 to 5.5 mm., width 2 to 2.5 mm.

Head: Antenniferous tubercles very small and close to the eyes. Rostral lobes prominent though not reaching the apex. First segment of antennae just reaching the apex of the head. Eyes prominent.

Pronotum much narrower in front than behind. Transverse suture reaching to the borders of the pronotum. Scutellum narrowing rather abruptly near the base; slender near the apex which is rather sharp and somewhat elevated. Borders of apical portion raised.

Abdomen but little wider than pronotum. Genitalia: Dorsal plate in female broadly triangular with rounded apex. Ventral plate with posterior angles evenly rounded. Dorsal plate in male produced and spatulate. Ventral plate wider at the edges and middle, almost as long as dorsal plate. Wings as long as or a little longer than the abdomen. Pubescence medium. Punctuations coarse but not tubercular.

Color: This species is so variable in color that little use can be made of this character for the purpose of identification. Red and yellow predominate, and black is usually wanting except on disk of abdomen and wing spots, and even from here it sometimes disappears. The red varies from bright to pale. In some cases the head and thorax are red and the under side of abdomen a bright yellow. Occasionally lateral reddish brown stripes are found on the under side of the abdomen, especially in the males. The color scheme on the disk of abdomen consists of a large transverse spot at the base, two lateral longitudinal areas about the middle, the spot on anal segment and three small spots on the enclosed area, black or reddish. These areas may increase in size until they cover the entire abdomen except the anal segment, or they may entirely disappear. Connexivum, except in very rare cases, without spots. Sternum black, reddish or colorless.

This is a widely distributed species in the U. S. and seems to be more abundant in the south. Specimens are at hand from practically every part of the United States.

Corizus validus Uhler.

Corizus validus Uhler, Proc. Ent. Soc. Wash. p. 370 (1893).

Closely resembling lateralis in form and color. Very large. Rare. Length of female, 7 to 8 mm., width 3.5 to 4 mm. Male, length 7 to 7.5 mm., width 3 to 4 mm.

This insect differs so little from lateralis that it is doubtful if it should be retained as a separate species. The head and thorax characters are practically identical. The scutellum is a little broader in the last third of its length, and the apex is a little more sharply pointed.

There is little difference in the genitalia, and what is noticeable might disappear if sufficient material were at hand. In the female the posterior angles seem to be rather more rounded than in lateralis, and in the male the widening of the middle portion of the ventral plate seems to be a little more pronounced, thus giving it a longer and sharper point when viewed from the side. In the

female the ventral plate is frequently notched at the apex. This rarely occurs in lateralis.

In color there is little difference. It has the same variable character, and the dorsal picture is often the same. The connexivum, however, usually has a small spot on each segment, while in lateralis this rarely occurs.

It is not widely distributed, and seems to be confined to the mountains. Specimens are at hand from Cal., Utah and Wyo.

Corizus sidae Fabricius.

Lygaeus sidae Fabr., Ent. Syst., IV, p. 169 (1794).
Coreus sidae Fabr., Syst. Rhyng., p. 201 (1803).
Coreus (Rhopalus) sidae, Guer. in Sagra. Hist. de Cuba Ins. p. 385 (1857).
Rhopalus pictipes Stal, Freg. Eug. resa. Ins. p. 239 (1859).
Corizus sidae Sign., Ann. Soc. Ent. Fr., Ser. 3, VII, p. 95; Stal, Hem. Fabr., I, p. 69 (1868).
Corizus mexicanus Sign. Ann. Soc. Ent. Fr., Ser. 3 VII, p. 95 (1859).
Corizus proximus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 96 (1859).
Corizus nebulosus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 98 (1859).
Corizus pictipes Stal, Ent. Zeit. XXIII, p. 307 (1862).
Corizus anticus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 99 (1859).
Corizus ventralis Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 92 (1859); Distant, Biolog. Cent. Amer. pl. XV, fig. 23.

Small pointed head; abdomen broad and short. Abdominal picture appearing as a dark band across the middle of abdomen. Length of female, 5.6 to 6.3 mm., length of male, 4.4 to 5.5 mm. Female, width 2.9 to 3.1 mm., male, width 2 to 2.5 mm.

Head narrowly triangular. Antenniferous tubercles scarcely visible and placed very close to the eyes. Rostral lobes short but well defined. First segment of antennae scarcely reaching apex of the head.

Pronotum narrowing decidedly anteriorly and quite convex. Transverse suture bordered in front by a tubercular ridge. Scutellum rather sharply pointed and excavated at the tip.

Abdomen short and much wider than thorax, narrowing rapidly from fourth segment, and becoming depressed. Genitalia: Dorsal plate in female broadly rounded at the apex. Ventral plate short, uniform in width, posterior angles round. Dorsal plate in male convex, short. Ventral plate much narrower at the middle than at the edges. Wings longer than the abdomen. Pubescence soft on the body and heavier on the legs. Punctuations rather coarse.

The general color varies from dark brown to gray or reddish yellow, usually rather thickly covered over with very small brown or bright red spots, and often with both colors intermingled. The whole insect, especially in the tropics, often has a metallic luster, making it the most beautiful of the genus when viewed under the lens. A dark line begins on the head and extends backward on the pronotum, where it widens and is lost.

The abdominal picture varies greatly, but the first segment is usually darker while the second is light except at its middle where there are frequently three small spots. The third, fourth and fifth are nearly always dark, and often black; the fifth having a light spot at its center. The sixth segment is all light in the female and with a dark stripe at its middle in the male. Connexivum light; the third, fourth and fifth segments having each a darker spot which usually has a light spot or line at its center. This latter may be absent, as also the dark spot on the third segment. Sternum black. On the legs, the small spots that cover the body, form well marked rings.

This species is widely distributed in tropical America. Berg, in his Hemiptera Argentina, p. 93 (1879), reports it from the Argentine Republic, Patagonia and Brazil. Uhler in various articles reports it from Texas, Indian Territory, Arizona, Mexico, Brazil, Maryland (once only), and Lower California. Specimens are at hand from Georgia, Florida and Arizona, in the United States, and from Mexico, Guatemala, Cuba, Hayti, Trinidad and St. Vincent.

Corizus parvicornis Signoret.

Corizus parvicornis Sign., Ann. Soc. Ent. Fr., p. 301 (1859).

Very small. Short and thick in appearance. Neck short. Length of female 3.5 to 5 mm., width 2 to 2.5 mm. Male, length 3 to 4 mm., width 1.5 to 2 mm.

Head: Antenniferous tubercles short and rounded. Rostral lobes small and obscure. Antennae short. First segment reaching apex of head. Head narrowing very abruptly behind the eyes, thus bringing the latter very close to the angles of the prothorax.

Pronotum short. Transverse suture much curved and bordered anteriorly by a prominent ridge. Scutellum large, about one-third as long as the abdomen; apex broad though rather abruptly drawn to a point; the borders about the large excavation prominently raised.

Abdomen a little wider than prothorax. Genitalia: Dorsal plate in the female a little produced and broadly rounded. Ventral plate widest at its middle with posterior angles broadly rounded. In the male the dorsal plate is much produced, and the ventral is equal in width throughout. Wings, little if any longer than the body, and sometimes not reaching the extremity of the abdomen. The whole insect has a short thick appearance which is very characteristic. It is thinly covered with rather long hair. Punctuations large.

Color: Varying from gray to almost black, without distinctive markings except on the disk of the abdomen, which is black or brown. There is a small obscure light spot about the middle of the fourth segment, and two each on the anterior borders of the third and fifth. The transverse suture, and a few spots on the wing veins are black. The sixth segment has the common black spot in the middle and sometimes the light borders may be divided by the enlargement of this spot, thus forming two light spots at the anterior margin. Connexivum spotted. The sternum is black and the legs are spotted with the same color or with brown. These spots usually form pretty well pronounced rings. In very dark specimens the whole under side is covered over with dark or black blotches.

This is the smallest species of the genus and seems to be rather rare. Specimens are at hand from California, Texas and Mexico.

Corizus nigristernum Signoret.

Corizus nigristernum Sign., Ann., Soc. Ent. Fr., p. 100 (1859).
Corizus Bohemani Sign., Ann. Soc. Ent. Fr., p. 86 (1859).

Very dark in color. Spot on abdomen above, in form of an X. Length of female 5.5 to 6 mm., width 3 mm. Length of male 5 to 5.5 mm., width 2.5 to 3 mm.

Head: Eyes rather prominent. Antenniferous tubercles small and close to the eyes. Rostral lobes short, clearly marked.

Pronotum decidedly narrower in front than behind. Transverse suture a slender line bordered anteriorly by a slight elevation. Median line prominent.

Scutellum sharp pointed and not excavated. Lateral borders raised, except at their middle points.

Abdomen but little wider than prothorax. Genitalia: Dorsal plate in female a little broader than long; apex pointed. Ventral plate widest at its middle, and the posterior angles practically wanting. Dorsal plate of male somewhat produced and broadly rounded; ventral plate widest at the middle; posterior angles rounded. Punctuations normal. Pubescence short and soft. Wings about as long as the body.

Color: Rather dark reddish or yellowish brown, frequently almost black. Apex of head, and small spots between ocelli and eyes, black. Median line of pronotum light, extending onto scutellum, the borders of which are also light on the elevated portions. Disk of abdomen dark brown or black, with a light spot, near its middle, in the form of an X. This spot may be much reduced, or it may be enlarged to form a large irregular blotch. Last segment light, with a black stripe very much enlarged laterally, enclosing two light spots at its anterior border. This enlargement is often obscure or wanting, especially in the female. Connexivum, light, spotted with black. Beneath, uniform light yellow or reddish brown. Sternum black. Wing veins spotted with dark red or black. Legs yellowish with dark spots.

This species is eastern in its distribution, and apparently does not extend far south. Uhler has reported it from the east and also from the south-west, Arizona, Texas, California, and Lower California, but the species to which he refers here is probably indentatus, which has a slight superficial resemblance to nigristernum. Specimens are at hand from Canada, Ohio, Pennsylvania, New York, West Virginia, Virginia, Maryland, District of Columbia and Missouri.

Signoret evidently had two extreme types of this insect and hence described it twice as different species.

Corizus punctatus Signoret.

Corizus punctatus Sign., Ann. Soc. Ent. Fr. p. 81 (1859).—Distant, Biol. Cent. Am., pl. XVI, fig. 8 (1881).

Somewhat resembling nigristernum in general shape and color, but with last segment of abdomen much more produced. Length of female 5.5 mm., width 2.5 mm. Length of male 4.5 mm., width 2 mm.

Head: Eyes very prominent. Antenniferous tubercles short and broad, rounded at the tips. Rostral lobes slender but reaching almost to the apex of the head, but not clearly marked. First segment of antennae slightly passing the apex.

Pronotum much narrower in front than behind. Region of transverse suture not tubercular. Scutellum rather sharp with a very small excavation at the apex.

Abdomen very little wider than the thorax. Sixth segment very long, pointed. Both dorsal and ventral plates in the female are sharply triangular, and the ventral is but little shorter than the dorsal. In the male the dorsal is somewhat produced with apex rounded. Ventral plate much widest at its middle point. Wings about as long as the abdomen. Pubescence short and soft. Punctuations normal.

Color, dark reddish brown or almost black above, and reddish yellow or yellow, below. The eyes and ocelli are red, the latter bordered by a black spot. The head has a blackish longitudinal line running throughout its length. Wing

veins sparingly spotted with black. Abdomen above, black with three small light spots, one on the fourth segment and two on the fifth, the sixth has the conventional black stripe bordered by lighter color. The connexivum is light with a small black spot on each segment.

Too much confidence should not be placed in this color description. The insect is rare, at least in collections, and material at hand was not sufficient to determine the limits of its variation. It is however, easily distinguished from all others by its genitalia. Specimens are at hand from Texas, Mexico and Hayti.

PHYLOGENY.

Any attempt to trace the lines of dispersal or phylogeny of this genus must be merely tentative until more is known of their life histories, food plants, etc. As far as known at the present time, hyalinus is by far the most widely distributed member of the genus, and from the fact that it is found in the tropics and sub-tropics, completely around the earth, we must concede to it very great antiquity. It probably penetrated into the United States by way of Mexico, and thence spread over the entire southern half of the country.

Sidae undoubtedly has originated in Central America or the West Indies, and has spread as far north and south as the climate or its food plant will permit. Parvicornis is rather an extreme type that is difficult to account for, though it is probably an offshoot from sidae, as it seems to be more closely related to it than to any other.

Crassicornis is circumpolar in its distribution, being found entirely around the earth in the north temperate zone, and even far into the boreal regions of North America and Eurasia. It is probable that it originated in the latter continent and thence found its way to America. The winds and tides would favor a migration in this direction, rather than in the opposite. Viridicatus is plainly a mountain offshoot from this species.

Scutatus, indentatus and tuberculatus are three species that in many respects, are closely related, and seem to have sprung from a common type. They are all western, and as far as known, not widely distributed, and occupy the same territory. The remaining four species, namely, lateralis, validus, nigristernum and punctatus, form one lateral branch that seems to have sprung from the hyalinus type. Lateralis is the most widely distributed and occupies, practically, all of the United States. Validus is a mountain form very closely related to lateralis, and is not com-

mon nor widely distributed. Nigristernum occupies the eastern United States and Canada, while its closely related species, punctatus, is from the southwest, Mexico and the West Indies.

Hyalinus and crassicornis are the only American species that are also found in the Old World. It seems more than probable that these have both emigrated to this country, hyalinus by the southern route and crassicornis by the northern, and here given rise to our peculiarly American species. From the latter, undoubtedly we get viridicatus, while all the remaining species seem to have sprung from the hyalinus stock.

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EXPLANATION OF PLATES.

PLATE VIII.

Corizus hyalinus ♀
" crassicornis ♀
" tuberculatus ♀
" sidae ♂

PLATE IX.

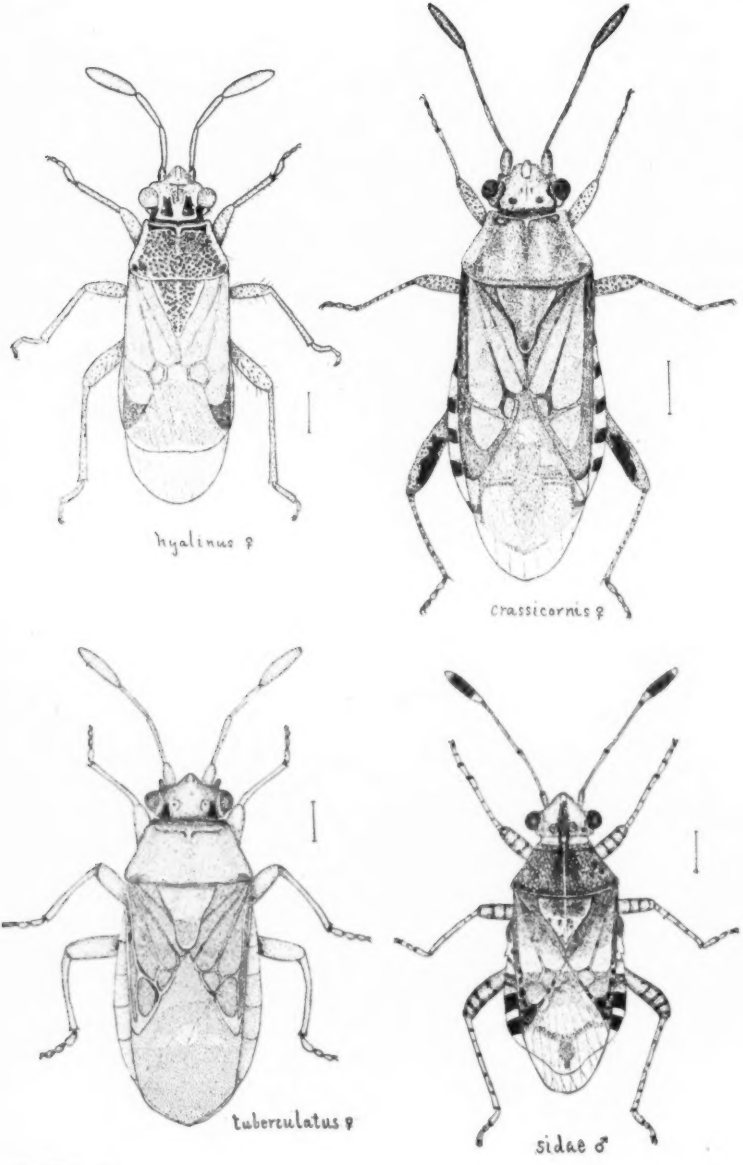
FIG. 1. Abdominal disk of hyalinus ♀
" 2. " " " crassicornis ♀
" 3. " " " viridicatus ♀
" 4. " " " scutatus ♀
" 5. " " " indentatus ♀
" 6. " " " tuberculatus ♀
" 7. " " " parvicornis ♀
" 8. " " " lateralis ♀
" 9. " " " validus ♂
" 10. " " " sidae ♀
" 11. " " " punctatus ♀
" 12. " " " nigristernum ♀

PLATE X.

FIG. 1a ♂, 1b ♀, genitalia, side view, 1c, head, 1d, scutellum of hyalinus.
" 2a ♂, 2a ♀, " " " 2c, " 2d, " crassicornis.
" 3a ♂, 3b ♀, " " " 3c, " 3d, " viridicatus.
" 4a ♂, 4b ♀, " " " 4c, " 4d, " scutatus.
" 5a ♂, 5b ♀, " " " 5c, " 5d, " indentatus.
" 6a ♀, " " " 6b, " 6c, " tuberculatus.

PLATE XI.

FIG. 7a ♂, 7b ♀, genitalia, side, view 7c head 7d, scutellum of parvicornis
" 8a ♂, 8b ♀, " " " 8c, " 8d, " lateralis.
" 9a ♂, 9b ♀, " " " 9c, " 9d, " validus.
" 10a ♂, 10b ♀, " " " 10c, " 10d, " sidae.
" 11a ♂, 11b ♀, " " " 11c, " 11d, " punctatus.
" 12a ♂, 12b ♀, " " " 12c, " 12d, " nigristernum.



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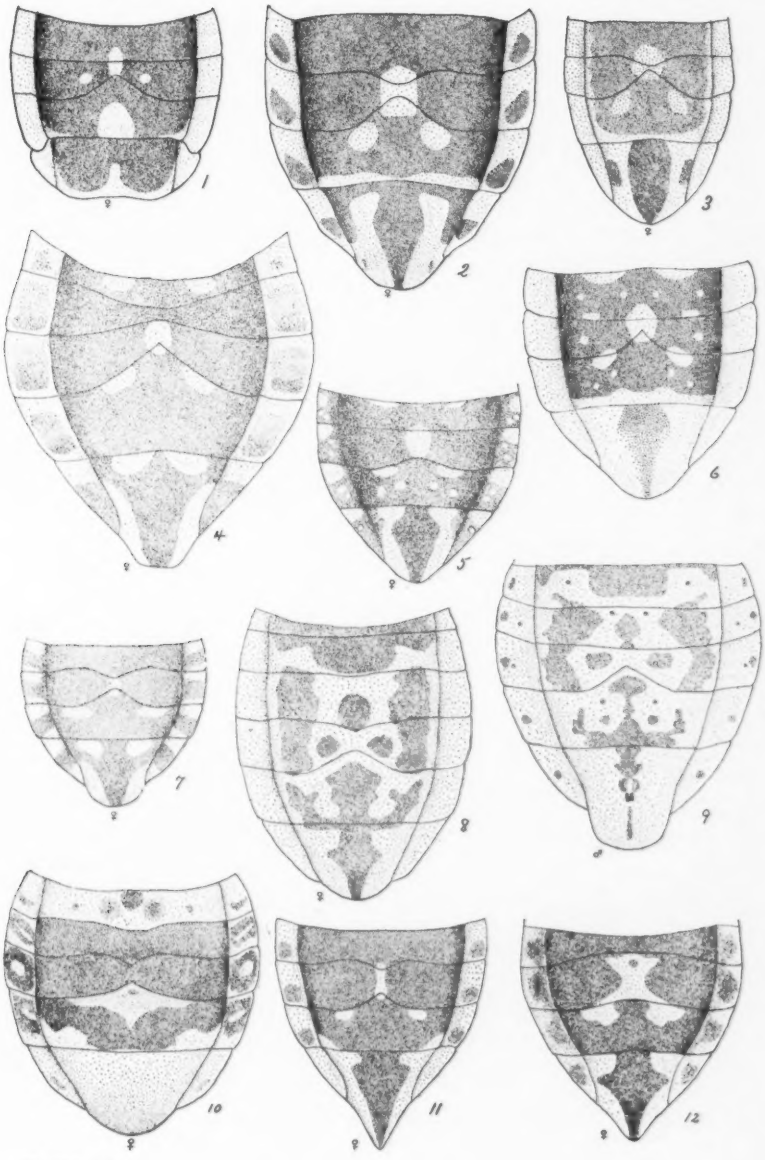

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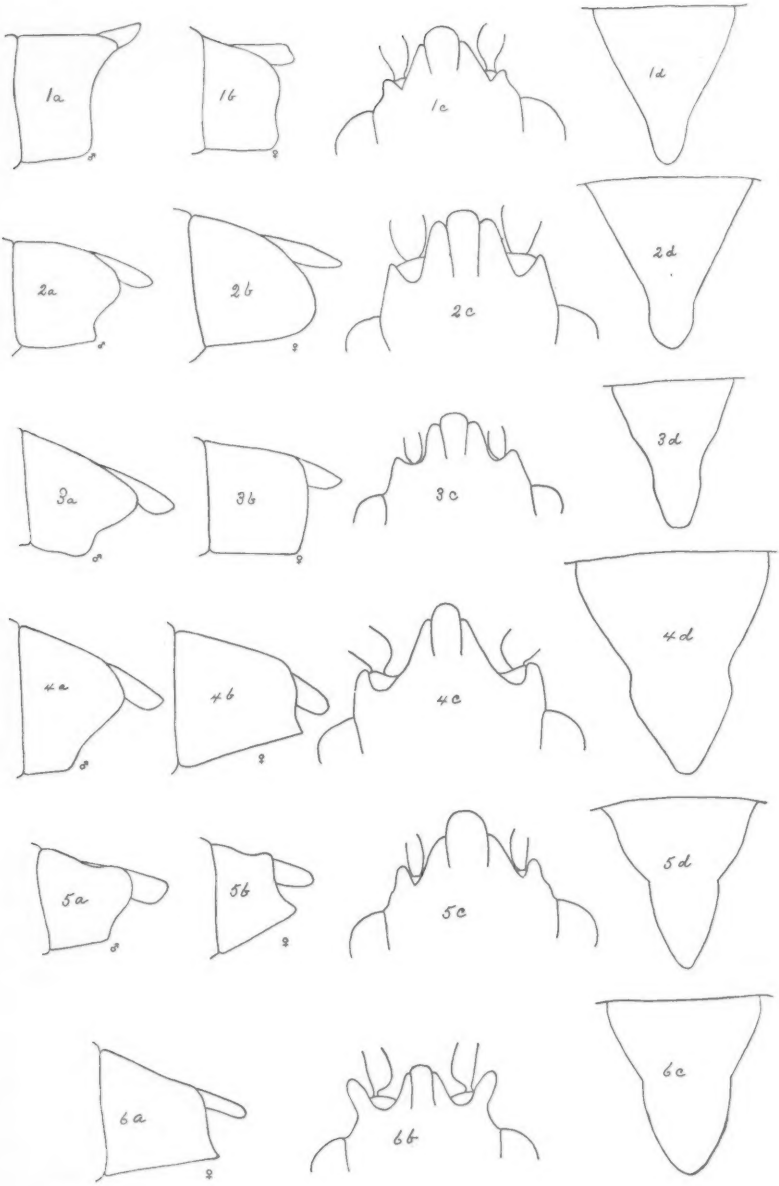

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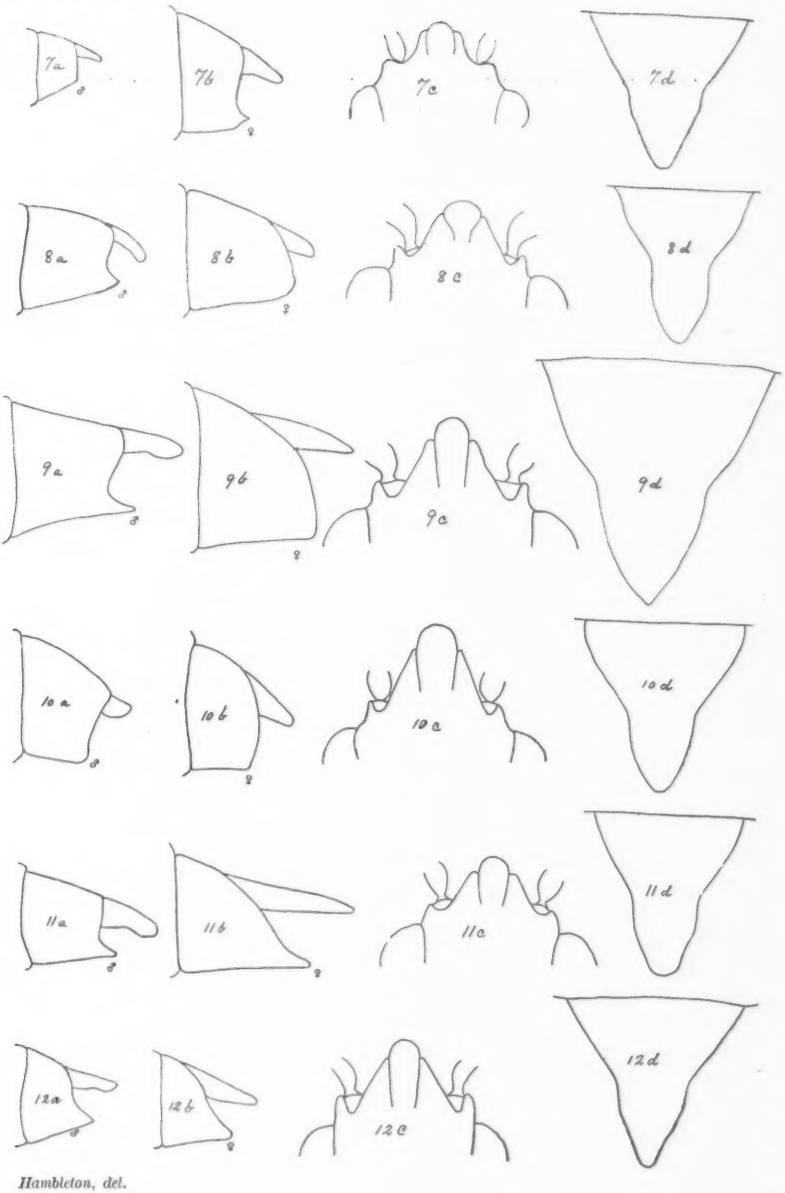

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THE ENTOMOLOGICAL SOCIETY OF AMERICA AND ITS WORK.*

By Henry H. Lyman, M. A., Montreal.

It is with considerable diffidence that I venture to address the members of the Entomological Society of America on the work of the new Society, and trust that I may not be thought guilty of presumption in so doing.

It was, naturally, a source of gratification to me that the Society, should be brought into existence under such happy auspices and secure such warm support from so large a number of the most eminent entomologists of the Continent, and I have as much reason as the able officers and Executive Committee for hoping that it will fill a useful role in the history of North American entomology. But in order that this may be so and its existence justified, several conditions are necessary.

If it were to be mainly a society of professional entomologists, it might well be questioned why it should exist in addition to the Society of Economic Entomologists, as, at least on this Continent, almost all professional entomologists are, of necessity, economic ones. It seems to me that the Society will fall short of its highest usefulness if it fails to secure the support and co-operation of the great body of amateur entomologists, and that its usefulness will be in proportion to its success in bringing amateurs and professionals into touch with each other, and in winning both to the support of its aims. But what are its aims? According to the Constitution, "It shall be the purpose of this Society to promote the science of entomology in all its branches, to secure co-operation in all measures tending to that end, and to facilitate personal intercourse between entomologists."

This is the official statement of the aims of the Society in the broadest and simplest words, but may we not with advantage elaborate them a little more. To take the last item first, viz.: "To facilitate personal intercourse between entomologists;" so far as this is accomplished, it must be productive of much good, as the better we know each other the better we should understand each other, and if we understand each other and desire to

* Read before the Society at Chicago, December 30th, 1907.

avoid causes of difference, the easier it should be to do so. Then it should be an inspiration to an amateur or beginner to know that he is a fellow member with all the most eminent entomologists of the Continent, and should be a spur to his ambition to do some good work in the science worthy of the Society.

But there must necessarily be many members, especially among the amateurs, who can hardly hope to come into personal touch with the leaders of the science through their inability to attend the meetings, and there is much danger of such members losing interest in the Society and dropping their membership, and to guard against that, I would strongly urge that we should publish something. I entirely agree with the view of the Publication Committee, that it is not desirable to take over any existing journal nor to publish anything that would occupy the field of any existing journal, or to make any of the current periodicals the official organ of the Society. The publication of a journal would hardly be feasible, unless the Society had a fixed headquarters, and that would tend too much to localize it and detract from its breadth of character. The suggestion, that we should sometime undertake the publication of a dignified series of publications in the form of "Annals" or "Memoirs," which would be distinctly creditable to American Entomology, is to be commended, but I respectfully submit that we should not wait until we are in a position to enter upon so large and important a project. Such publications, especially if well illustrated, are costly and could hardly be issued free to our members, unless the annual subscription were greatly raised, and I would, therefore, suggest, in order to keep the scattered members in touch with the movement, the issue of an annual report containing the constitution and by-laws, alphabetical list of members with their addresses, lists of fellows and honorary fellows, detailed reports of the meetings held and of the action of all committees, the President's or presiding officer's annual address, and such papers read before the Society as are not reserved by their authors for publication through some other channel, and that this report be mailed free to all members, who would thus see that they were getting something for their membership and were not forgotten.

In regard to the main objects of the Society, viz., the promotion of the science of entomology in all its branches and the securing of co-operation in all measures tending to that end, we may ask how are these ends to be attained? In the nature of

things, our general meetings must be few and far between, and coming as they do during the meetings of larger bodies, little time can be devoted to them. Under such conditions, it appears to me that the reading of papers should be only a minor part of the business at such meetings, as it makes very little difference, except for the opportunity of discussing them, whether papers are read to us or reach us through one of the many channels for publication, and might it not be well to reserve some of the time at our disposal for a general discussion on the Science of entomology and how our Society can best contribute to its advancement and be made continually more useful, as it seems to me of the highest importance that when we get a lot of prominent entomologists together, we should devote a considerable part of the time at our disposal to doing something to advance the general interests of the Science.

Might it not also be well, in view of the large membership of the Society, to remove, at least partially, the restriction limiting membership in the Executive Committee to Fellows of the Society, in order that the Committee may be enlarged and rendered more truly representative, enabling the amateurs to have better representation, and also making it possible to appoint a number of representative sub-committees for the purpose of dealing with various matters between meetings of the Society, such as the questions propounded by Dr. Felt at this meeting in regard to nomenclature, and preparing reports for presentation to the Society at its annual meeting.

Should not the Society also exert its influence against any tendency to make entomological appointments in any way dependent upon political affiliations, or upon any basis except scientific fitness for the position, and is it too much to hope that the Society may be able to do something toward bring about some approach to stability of nomenclature, either by frowning upon needless and erratic changes or by itself issuing standard lists, which would represent the combined wisdom of the many, rather than the views of an individual.

I hope that at least some of the suggestions which I have ventured to make may be thought worthy of your consideration.

FURTHER BIOLOGICAL NOTES ON THE COLORADO POTATO BEETLE, LEPTINOTARSA DECEMLINEATA (SAY), INCLUDING OBSERVATIONS ON THE NUMBER OF GENERATIONS AND LENGTH OF THE PERIOD OF OVIPOSITION.

By Alec. Arsène Girault, Washington, D. C.

During 1907 I have tried to duplicate the observations on this insect made in Georgia in 1906 (Girault and Rosenfeld, 1907), and also to extend them in length of time, and in a measure have succeeded in making some interesting and rather important ones on its life history. These observations were made during time not otherwise employed with the duties connected with a field station, and hence they are not by any means as complete and extensive as they should be and are necessarily more or less desultory; they were also started somewhat late in the season. But notwithstanding these, the facts learned I consider of importance, particularly as they tend to supplement some of the results obtained by Tower (1906), which are not very well known to entomologists. Not enough observations were made in most cases to warrant final conclusions, and with this general warning they are submitted for publication.

The observations were made in the field laboratory of the Bureau of Entomology, U. S. Department of Agriculture, at New Richmond, Clermont County, Ohio, latitude 38 degrees, 48 minutes, north.

SUMMARY.

The following paper is based on observations made during a single season on two pairs of hibernated beetles, interbred to a second generation which reproduced, contrary to the results obtained by Tower (1906) for normal beetles. A record of oviposition is given for each generation, in the case of the hibernated pairs exceeding the average recorded by Tower for normal beetles. The length of life of the adults and the period of oviposition exceeds in each instance the average recorded by the same author. In addition to observations on these points, a number of records of the duration of the egg instar for different dates are given, together with observations on habits of the larvae and adults, and a few records of the duration of the post-embryonic instars.

The paper mainly deals, however, with observations on the adult, and especially on the number of generations per season and related points concerned with the function of reproduction, and the interpretation of these observations in the light of the recent work of Tower (1906). I have, therefore, freely interspersed quotations from this work, and discussed somewhat at length the evidence so far presented in regard to the number of cycles per season, reaching the general conclusion that my observations are indeterminate in value as far as this point is concerned, mainly because of paucity; that they tend, however, to throw the question open again, especially as Tower gives but a limited amount of evidence, and that the question is entirely undecided as far as out-door conditions are concerned. I have seen no valid reason to doubt Tower's statements, excepting that the data back of them have been withheld, and that unfortunate discrepancies arise from place to place throughout.

TABLE I.—Duration of the Egg Instar, New Richmond, Ohio, Season 1907.

Remarks.*	Lot No.	No. Eggs.	Deposited.			Hatched.			Duration.		Effective temp. Degrees Fahr. Daily Average.
			Month.	Day.	Time.	Month.	Day.	Time.	Days.	Hours.	
	1	44	May	31	2 pm	June	10	6 am	9	16	22.42
	2	58	June	1	9 pm		11	9 am	9	12	23.62
Pair No. 1	3	62		4	9 am		12	noon	8	3	23.72
	4	52		9	10 am		15	noon	6	2	27.14
Pair No. 1	5	30		12	3 pm		18	5 pm	6	2	28.32
Pair No. 1	6	10		18	1 pm		23	5 am	4	16	33.85
	7	36		18	4 pm		23	7 am	4	15	33.85
	8	30		20	1 pm		25	5 am	4	16	34.94
	9	44		24	11 am		29	1 pm	5	2	30.70
	10	29	July	5	5 am	July	9	6 am	4	1	35.75
	11	33		7	noon		11	4 pm	4	4	37.16
	12	41		8	noon		12	10 pm	4	10	36.56
Pair No. 1	13	33		12	12:30 pm		16	11:30 pm	3	23	33.20
	14	31		19	1:30 pm		23	10:30 am	3	22	38.94
Pair No. 1, 1st generation.	15	31		23	6 pm		28	6 am	4	12	
Pair No. 1 1st generation.	16	22		28	2 pm	Aug.	2	10 am	4	20	31.94
Pair No. 1 1st generation.	17	21		29	1 pm		3	noon	4	23	32.38
Pair No. 1	18	7	Aug.	7	1 pm		11	8 pm	4	7	
Pair No. 1	19	28		13	7 pm		18	3 pm	4	20	
Pair No. 1	20	20		20	noon		25	4 am	4	16	
Lot No. 2 2nd generation.	21	39	Sept.	4	3 pm	Sept.	10	noon	5	21†	28.28†
Lot No. 1 2nd generation.	22	9		5	noon		11	6 am	5	18†	
Sums	22	710							107	281	532.77
Averages									5.40		31.34

* These refer to the hibernated pairs unless otherwise stated; and unless noted, all of these eggs are from pair No. 2 of the hibernated individuals.

† Approximated.

THE EGG.

1. *Length of Instar.* The duration of the egg instar has been determined for over seven hundred cases at different dates during the breeding season and the records are tabulated in table I. Each separate batch of eggs was confined immediately after deposition in an ordinary pasteboard pill-box, and they were thus in darkness. Moisture was supplied by the daily addition of fresh foliage. The temperature was the most apparent variable factor during development.

The effective temperatures were not determined in five cases, but enough are recorded to show that during the period covered the instar is about inversely proportional to the variation in temperature; that is to say, when the instar is long, the daily average effective temperature is low, and conversely. These records should have been made from a thermograph and calculated on the basis of hours; instead, I had to depend on maxima and minima for daily averages, and hence fractions of days had to be largely ignored. Undoubtedly, therefore, the records of effective temperatures in table I are more or less inaccurate. Forty-three degrees Fahrenheit is here assumed to mark the point of the inception of activity and reproduction, which as yet has not been determined for decemlineata. Wheeler (1889, p. 355) records the period of embryonic development as 6 days.

2. *Number of Eggs Deposited.* Our ignorance in regard to the average reproductive capability of our most common insects is profound, and this fact is well illustrated in the case of the Colorado Potato Beetle. I have simply to point out the fact that up to within the past two or three years its maximum oviposition was supposed to be in the neighborhood of 500 eggs, more probably less than that number. My observations on this point in 1907 are of importance because they show that this *estimate* is wrong, and also that with how slight an effort many of the facts of this nature can be learned more or less definitely. It was unfortunate that with the time at my disposal I was unable to make a large series of observations, thus obtaining maxima, minima, range, and average. William Lawrence Tower (1906) was the first to record actual observations on this point; apparently from a number of observations, on page 237, table 104, he records a range in oviposition of from 190 to 600 eggs, with an average of 450. The number of batches of eggs deposited ranged from 4 to 18 with an average of 12. Later (July 23, 1907,

in litt.), he states: "In regard to the number of eggs, on page 237 of my paper, you will find a table with the number of eggs laid by fifteen species of Leptinotarsa. In nature the average for decemlineata is 450—with a range of from 34 to 3700. I now have a female which has been laying eggs since April 12, and now has laid nearly 3,000 eggs. As she is in good condition, I expect to get from 3,500 to 4,000 eggs from her. This is a special race but shows the great range and the length of life of the adults. The reproductive period is in this race from 3 to 4 months long." It must not be understood from this quotation that the range of oviposition of from 34 to 3,700 as there stated is given in the place referred to (namely, Tower, 1906, p. 237, table 104), and I have since received the following from Professor Tower in regard to that statement (Tower, *in litt.*, April 21, 1908): "In regard to the number of eggs laid by Leptinotarsa decemlineata, the figures which I gave you last July were from unpublished data. The data to which you refer in my paper of 1906 are quite incomplete in regard to a lot of biological data which I did not feel like publishing at that time. There are some races of various species of Leptinotarsa which have laid eggs far in excess of 3,700, but these of course are special races. There was no mistake in giving the data. I simply gave you data which was unpublished."

Professor Tower has therefore obtained races which produce eggs far in excess of the normal beetles and which also have a much longer period of reproduction. The following account, of course, concerns normal beetles only, and so far as it goes, exceeds the averages obtained by Tower (1906) as far as reported for normal beetles.

Inasmuch as the period of oviposition and number of eggs deposited varied with the generation, the following table has been prepared showing the results obtained with the few pairs I was able to care for. Unfortunately, I was unable to keep a parallel series under field or natural conditions. This table also contains a number of observations closely connected with the function of oviposition, but difficult to present in any other form.

The table shows quite a range in oviposition according to generation, but as I have already indicated the observations are on too small a scale to allow general conclusions.

The first two pairs of hibernated adults were captured while mating in a potato field near New Richmond, Ohio, at 4 P. M., May 29, 1907, and each immediately confined in a glass jar cov-

TABLE II.—Number Eggs Deposited in Confinement by Pairs of Different Generations. Ohio. 1907.

Mass No.	Generation: Hibernated (Parents of 1st generation)				Generation: I (Parents of 2nd generation)				Generation: II (Parents of 3rd generation)			
	1st mating observed May 29, 4 p. m.				1st mating observed July 22, 10 a. m.				1st mating observed Sept. 1.			
	Pair No. 1		Pair No. 2		Pair No. 1		Pair No. 2		Lot No. 1		Lot. No. 2	
	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs
1	June am 1	91	May 2 pm 31	49	July 3:30pm22	7	July 27 by pm	10	Sept. 4	6	Sept. 2	2
2	9 am 4	28	June 9 pm 1	58	6 pm 23	31			noon 5	16	3 pm 4	39
3		34	10 am 6	68	by pm 27	156			7	9	am 6	24
4	noon 5	20	10 am 9	52	2 pm 28	22						
5	11 am 6	9	11	20	1 pm 29	21						
6	pm 8	8	am 12	61	1 pm 30	28						
7	pm 9	43	14	21	pm 31	16						
8	2 pm 10	14	pm 16	17	Aug. am 3	20						
9	3 pm 12	30	am 18	17	am 3	26						
10	3 pm 15	33	4 pm 18	36	pm 4	27						
11	1 pm 17	6	pm 19	21	pm 6	17						
12	1 pm 18	10	1 pm 20	31								
13	am 19	21	21	71								
14	am 20	18	pm 22	48								
15	21	7	23	29								
16	23	41	11 am 24	44								
17	pm 24	12	26	46								
18	10 am 25	26	27	33								
19	26	31	pm 28	36								
20	27	18	July am 2	58								
21	30	6	pm 3	19								
22	July 4	15	am 5	29								
23	6	19	pm 5	26								
24	am 7	23	4 pm 6	35								
25	am 8	40	noon 7	33								
26	pm 8	16	noon 8	41								
27	By pm 11	60	am 9	18								
28	12.30 „ 12	33	by pm 11	41								
29	by am 14	13	am 16	22								
30	pm 15	14	pm 18	24								
31	pm 17	28	1:30pm19	31								
32	pm 18	13	pm 20	31								
33	pm 20	48	pm 21	11								
34	pm 21	17	pm 23	12								
35	11 am 22	23										
36	pm 23	25										
37	By 27	1										
38	Aug. am 2	11										
39	am 6	14										
40	pm 6	12										
41	1 pm 7	7										
42	pm 10	23										
43	am 11	14										
44	am 13	10										
45	7 pm 13	28										
46	By4pm16	10										
47	By am 19	1										
48	noon 20	20										
49	pm 23	51										
50	2 pm 24	2										
	Total	1097	Total	1189	Total	371	Total	10	Total	31	Total	65
	Average: 1143 eggs.				Average: 190.5 eggs.				Average: 48 eggs.			
	No. batches 50 Av. per batch 21.94 Daily average 12.90		No. batches, 34 Av. per batch. 34.97 Daily average 22.01		No. batches, 11 Av. per batch 33.72 Daily average 24.73		No. batches, 1 Av. per batch 10 Dailyaverage 10		No. batches, 3 Av. per batch 10.3 Dailyaverage 10.3		No. batches, 3 Av. per batch 21.6 Dailyaverage 16.25	

ered with cheese-cloth and containing fresh soil and potato foliage. They were kept in the shade on a counter in the laboratory, and supplied fresh foliage daily. The pairs of the first generation are direct descendants of pair No. 2 of the hibernated pairs, and the two lots of the second generation are descendants of pair No. 1 of the first generation (*Vide seq.*, history of generations). These later pairs were confined in a manner similar to the first two, in the first generation, all of the individuals together until mated, and in the second generation the pairs were not separated from the whole lot.

It is clear from the table that the hibernated pairs deposited very many more eggs than did the pairs of the first generation, and in proportion, the first generation many more than did the pairs of the second. The average number of eggs deposited by each generation is given in the table; the average for the three groups of pairs is 460.5 eggs, but this has no relation with Tower's (1906) average of 450 eggs which I believe is intended as the average of any one pair in any one generation. The number of eggs and the number of batches of eggs deposited by the pairs of the hibernated individuals is the largest ever recorded for normal beetles, the latter ranging from 34 to 50, with an average of 42. Tower (1906, l. c.) records the range in batches of eggs to be from 4 to 18, with an average of 12. The average number of eggs per batch or mass ranges from 10 to 34.94 eggs, and the daily rate of oviposition from 10 to 24.73 eggs.

3. *Color of the Eggs First Deposited.* It may be mentioned in passing that the first eggs deposited by the pairs of the first generation were distinctly more reddish than usual; in pair No. 1 not becoming normally colored until the third mass was deposited (July 24th to 27th), and with Pair No. 2, the one mass of eggs deposited was of reddish hue, and the same was true of all of the eggs deposited by adults of the second generation. The coloring matter in the first eggs deposited appears to be richer, and becomes faded somewhat or less dense in the later eggs which are probably more mature before leaving the ovaries. A partial explanation of this is apparently given by Wheeler (1889). All of these eggs were fertile. On September 6th, a recently deposited mass of 29 eggs found in the field were of the same color and proved to be fertile.

THE LARVA.

1. *Length of Instars.* Observations on this point were not extended owing to the fact that it was impossible to make them continuous in time. Larvae hatching from 49 eggs (deposited at 2 P. M., May 31st, by pair No. 2 of the hibernated individuals) at 6 A. M., June 10th, molted for the first time at 9 P. M., June 15th; the time of other ecdyses not recorded. Forty-four larvae hatching at 5 A. M., June 25th, molted for the first time at 6 A. M., June 28th, and for the second time at 7 A. M., July 1, but the time of the third ecdysis was not recorded. The following table shows the only complete observation made on the duration of the larval instars.

TABLE III. DURATION OF LARVAL INSTARS FOR A SINGLE CYCLE. 1907.

Lot No.	No. larvae.	Hatched.	1st ecdysis Instar I.	2nd ecdysis Instar II	3rd ecdysis Instar III	Entered soil Instar IV	Sums		Total effective temperature. Degrees Fahr.
							Days.	Hours	
1	13	8 a. m. Aug. 30.	11 p. m. Sept. 1	4 p. m. Sept. 4	3 p. m. Sept. 8	5 p. m. Sept. 11			
			2 da., 15 hr.	2 da., 17 hr.	3 da., 23 hr.	3 da., 2 hr.	12	9	387.5°

2. *Number of Ecdyses.* The number of ecdyses recorded for fifty larvae during the season of 1907 was three (3), excluding pupation, and there were thus four distinct larval instars (*Vide* Girault, 1907).

3. *Length of Stage.* The duration of the larval stage was correctly determined for a few lots only; the observations on several others being interrupted at critical periods, thus destroying accuracy. The accompanying table summarizes.

TABLE IV. DURATION OF THE LARVAL STAGE FOR THREE CYCLES, 1907.

Lot No.	No. larvae.	Source.	Hatched.	Entered soil.	Duration		Average daily effective temp. degrees Fahr.
					Days	Hours	
1	30	Pair No. 2. Hibernated pairs.	5 a. m., June 25.	6 p. m., July 6.	11	13	30.8
2	21	Pair No. 1, 1st generation.	Noon, August 3.	10 a. m., Aug. 14.	10	22	32.0
3	13	Pair No. 1, Hibernated pairs.	8 a. m., Aug. 30.	5 p. m., Sept. 11.	12	9	29.8°

4. *Habits; Eating of Eggs in Nature by Young Larvae.* On September 6th, 1907, I observed a mass of 32 eggs on a potato plant in the field. These eggs were in the process of hatching, ten larvae having already excluded, and the remaining embryos being on the point of doing so. The ten very recently hatched larvae were busily making their first meals on the remaining unhatched eggs in the mass, nearly all of the perfect embryos in them having already been killed. The potato plants were in good condition, though it was rather late, and breeding was still in progress in this field; an abundance of food was at hand. This habit was previously observed in confinement (Girault and Rosenfeld, 1907, p. 53), and was then attributed to starvation. As yet it is impossible to say to what extent this occurs.

5. *Length of Life of Instar I, in Confinement without Food.* Three lots of larvae, during the second and third weeks in June, were allowed to hatch in the paste-board boxes, and then left to starve. Each lot remained together in a mass for a day or two, and then scattered and began to wander. With one or two exceptions, all of them died at about the same time. The table summarizes.

TABLE V. Length of Life in Confinement without Food, Instar I.

Lot No.	No. larvae.	Hatched.	Died.	Length Life. Days.
1.	58	9 a. m., June 11.	June 16.	5
2.	62	Noon, June 12.	June 16.	4½
3.	52	Noon, June 15.	6 a. m., June 20.	4¾
Sums	172			14.25
Averages				4.75

THE PUPA.

1. *Duration of Stage.* The few observations recorded on this point are briefly tabulated as follows:

TABLE VI. Duration of Pupal Stage, Actual Time in Soil, Different Dates. 1907.

Lot No.	No. pupae	Entered soil.	Adults emerged.	Length of time in soil.	Sums of effective temperatures, deg. Fahr.
1	40	6 p.m., July 6	12:30 p.m. July 17	10 das., 18½ hrs.	391.3°—35.5° daily average.
2	15	10 a. m., Aug. 14	10 p.m., Aug. 27*	13 das., 12 hrs.	†
3	11	5 p. m., Sep. 11	10 a. m., Sep. 25	13 das., 17 hrs.	†

* Average time: 4 at 10 a. m., Aug. 26th; 7 at 10 a. m., Aug. 27th, and 3 at 7 to 10 a. m., Aug. 29.
† Hiatus in records.

THE ADULT.

1. *Length of Life in Confinement.*

a. In pairs normally reproducing. The results obtained on this point are important, indicating as they do a very much longer adult life than formerly believed, and even going beyond the records of Tower (1906, p. 231, table 103). With Tower in normally reproducing adults, over 88 per cent. had died by the twenty-fifth day, 67 per cent. by the twentieth day. My experiments were necessarily on a much smaller scale, yet all of the pairs kept by me, and in fact all of the adults recorded in following, confined together, lived considerably over the periods recorded by Tower. For instance, the hibernated pairs of the wintering generation, captured mating at 4 P. M., May 29th, and at once confined and supplied daily with food, reproduced continuously and did not commence to die until after the middle of the following August; the male of Pair No. 2 died on August 16th, the female of Pair No. 1 on August 28th, after not quite three months, the female of Pair No. 2, not until October 6th, much over four months after capture and the male of Pair No. 1 did not die until April 6, 1908, after it had been in hibernation since July 2, 1907, emerging on February 26, 1908.

As Tower points out (1906, l. c.), these records may be due to exceptionally long-lived individuals. Table VII summarizes.

TABLE VII. LENGTH OF ADULT LIFE IN CONFINEMENT, NORMALLY REPRODUCING.

Lot No.	No. individuals		Source.	Date confined, 1907.	Date of death, 1907.		Length of life, months.	
	Male	Female		Emergence	Male.	Female.	Male.	Female
I. Hiber.								
1	1	1	Potato field	4 p. m., May 29	1. Ap. 6, 08.	1. Aug. 28	10+	3+
2.	1	1			2. 5 p. m., Aug. 16	2. Oct. 6.	2.6	4.25
II. Gen.1								
1	1	1	Pair No. 2	12:30 p. m.	Hibernated,	Hibernated,	3.5(+?)	3.5(+?)
2	1	1	hibernated	July 17.	Nov. 1.	Nov. 1.		
III. Gen.2								
1	9		Pair No. 1	Aug. 26-27	Hibernated	Hibernated	2.2(+?)	2.2(+?)
2	4		gen. No. 1		Nov. 1.	Nov. 1.		

b. Mixed sexes, without food. A single lot of adults, survivals of 30 larvae hatching at 5 A. M., June 25th, and produced by Pair No. 2 of the hibernated individuals, and emerging from the soil in a large glass jar at 12:30 P. M., July 17th, were immediately fed and kept supplied with food until mating began on

July 22nd, when two mated pairs were removed to comprise the pairs of the first generation. The remaining 7 beetles of both sexes were fed until 10 A. M., July 27th, and then left to starve, and the soil in the jar allowed to become hard and dry. On the morning of August 11th, drops of water were added to the soil, and some of the adults drank of it; two of the beetles were then buried just below the surface of the earth. Nearly two months later, September 20th, three of the beetles died, and were found lying on the surface of the soil, which was now hard and caked, though it had been moistened from time to time. On September 25th, one adult was alive on the surface of the soil and the other three were exhumed alive; the soil was then dry and compact, but was again moistened from above on that date. The exhumed beetles again entered the soil; the one remaining above died on October 3rd. On October 17th, the three adults remaining were again exhumed alive and replaced on top of the soil, which they soon re-entered. Finally on November 1st, they were carefully examined and found in apparently good condition. They were placed on fresh, sifted soil, together with the male of Pair No. 1 of the hibernating individuals, allowed to enter it, and the jar containing them was placed in a place suitable for hibernation. They finally emerged on February 26 (1), April 7 (1) and April 11 (1), 1908, and are alive today (April 30, 1908).

Summarizing, the 7 beetles of mixed sexes lived as follows, after feeding was discontinued: 3 lived from July 27th to September 20th, or 55 days; 1 lived from July 27th to October 3rd, or 68 days; the remaining three lived at least until April 30, 1908, or over.

It is to be remarked that no reproduction occurred after food was discontinued, though a few eggs were deposited on July 23rd, during the period of feeding. As is to be expected none of the adults were observed mating either.

2. *Length of the Period of Oviposition.* By consulting table II, in which is given the number of eggs deposited by pairs of different generations in 1907, it is seen that the period of oviposition varied considerably for each generation, and was very much the longest for the pairs of the hibernated individuals. The table below makes the differences more apparent.

The period had a range of from 3 to 85 days, according to generation. Tower (1906, p. 237, table 104) gives the average

length of this period for normal beetles as 30 days*, but these figures are given on the supposition that there are but two generations which reproduce, the hibernated generation and the first generation (Ib, p. 243). An average of 32 days for the period of oviposition is obtained for the three generations, providing that Pair No. 2 of generation I is ignored, there having been no amount of reproduction with this pair. I should think it fairer, however, to consider averages for each generation, as the conditions are different with each, and especially so with the hibernated pairs which have a decided advantage in regard to available time for reproduction. It is apparent from previous tables that the period of oviposition is not directly dependent upon the length of life of the adults; that is to say, the latter may be much greater than the former which does not necessarily close with the death of the female. The reproductive periods appear to be more directly dependent upon the available food supply, the season of growth of the food plant, and similar factors, and I believe the short periods of the later generations may be thus explained, a view in direct conflict with Tower's (1906) limiting physiological principle.

TABLE VIII. LENGTH OF THE PERIOD OF OVIPOSITION, DIFFERENT GENERATIONS, 1907.

Generation No.	First mated.	First eggs Deposited.	Last eggs Deposited.	Length period of oviposition, days.
Hibernated—				
Pair No. 1	May 29, p. m.	a. m., June 1	2 p. m., Aug. 24	85
Pair No. 2		2 p. m., May 31	p. m., July 23	54
I.				
Pair No. 1	July 22, a. m.	3:30p.m. July 22	p. m., Aug. 6	15
Pair No. 2		By p.m., July 27	July 27	1+
II				
Lot No. 1	Sept. 1	Sept. 4	Sept. 7	3
Lot No. 2		Sept. 2	Sept. 6	4

3. *Mating.* With each generation, I have recorded the number of times which I have observed mating, but undoubtedly this act took place with more frequency than the records indicate, as I was unable to watch the pairs continuously, either during the day or night, and they are by no means complete. I tabulate these observations for convenience.

Pairs were observed mating twice on the same day (Pair No. 2, hibernated individuals), usually once in the morning and once

* For special races, however, as shown by the quotations from correspondence in foregoing, the period was much longer.

in the afternoon, but on July 6, twice in the afternoon; mating was observed at the following hours of the day: 3 P. M. (May 31); noon (July 15); 4 P. M. (May 29, July 21); 2 P. M. (June 5, Aug. 6); 10 A. M. (July 22); 11:30 A. M. (July 22); 11 A. M. (July 24); 4 P. M. (Sept. 5); 7 P. M. (Sept. 5); the observations seem to show that mating occurs as frequently in the morning as in the afternoon. The table also shows the relations between mating days and period of mating to period of oviposition and number of egg-masses deposited.

TABLE IX. FREQUENCY OF MATING IN REPRODUCING PAIRS, DIFFERENT GENERATIONS, 1907.

Generation No.	Pair No.	First mating.	Subsequent matings.	Last matings.	No. of matings	Observed period of mating, days.	Period of oviposition, days.	No. egg masses deposited.
Hibernated.	1	4 p. m. May 29	May 31. June 2,3,4,5,8,9,16, 17,18,20,23,24.	June 28*	15	May 29–June 28 30 days.	85	50
	2	4 p. m., May 29	May 31. June 3,10,12,13,17, 19,20,22,24,25,28, 29. July 1,3,3,4,4,5,6,6, 9,15,18,19,21.	Aug. 6†	28	May 29–Aug. 6, 69 days.	54	34
I.	1	10 a. m., July 22.		p. m., August 1‡.	2	July 22–Aug. 1. 10 da.	15	11
	2	11:30 a. m., July 22	July 24, 30, 31	Aug. 6•	5	July 22–Aug. 6, 15 da.	1+	1
II.	Lot 1	Not observed					3	3
	Lot 2	Sept. 1, approx.	4. p. m., Sept. 5	Sept 8°	3	Sept. 1–Sept. 8. 7 das.	4	3

* Male entered earth, July 2. † Male died, August 16. ‡ Male entered earth, p. m., Aug. 5th.
• Male entered earth, a. m., August 7th. ° Began to hibernate, Sept 7th.

4. *Potency of Fertilization.* No experiments were made to test this directly, but in the case of Pair No. 1 of the hibernated beetles some data have been obtained on it. Although the male left his mate on July 2nd and buried himself into the soil, the female continued to produce eggs until 2 P. M., August 24th, less than four days before her death, and 52 1-2 days after having been deserted by the male. During these 52 1-2 days, she deposited no less than 591 eggs or more than half of the total number deposited by her during the season; these eggs were deposited in 29 separate masses ranging from 1 to 60 eggs and averaging 20.3 eggs per mass; the daily rate of deposition for this mateless period was about 11.2 eggs. The eggs were tested for fertility at frequent intervals with positive results, and up until P. M.,

August 23rd, on the next to the last mass of 51 eggs. As compared to the period during which the male was present, a period of 34 days, 506 eggs were deposited in 21 masses ranging from 6 to 91 eggs and averaging about 24 eggs per mass, and with a daily rate of deposition of about 14.9 eggs; there is apparently some difference, as the daily rate of deposition fell after the male left, though his absence did not seem to matter very much. However, it is idle to speculate about a single observation of this kind. The simple fact is that the female continued to deposit fertile ova for many days after the male left.

It is well to note in this connection, the fact that oviposition in Pair No. 2 of the hibernated beetles stopped quite early, on July 23rd, 24 days before the death of the male and 74 days before that of the female; the female of this pair therefore lived for fifty days after the death of the male but deposited no eggs. I fail to account for the lack of production during this period, and merely mention the fact in order to show the singular difference in behavior between the two pairs. In Pair No. 1 of the first generation, both sexes disappeared beneath the soil at the same time, whereas in Pair No. 2 of the same generation, the male entered the soil fifteen days before the female, but again no deposition occurred after his desertion, and in this case but very little before.

5. *Number and History of Generations Reared in the Laboratory.* At 4 P. M., May 29th, 1907, as previously stated, two normal pairs of this insect were captured *in copula* in a potato field a quarter of a mile west of New Richmond, Ohio, and these were at once brought to the laboratory and confined, each pair separately, in a suitable glass jar containing moist soil and covered with cheese-cloth. They were kept constantly supplied with fresh potato foliage and soon began to produce a continuous series of eggs as shown in table II. These pairs were evidently hibernated individuals and they constituted the parents of the first generation.

Eleven adults emerging from the soil at 12:30 P. M., July 17th, being descendants of Pair No. 2 of the hibernated individuals (*cf.* table X) were confined together with food on that date, and on July 22nd, two of the pairs observed mating at 10 and 11:30 A. M., respectively, were transferred to separate jars; these constituted the parents of the second generation. Pair No. 1 of these two (*cf.* tables I and II) deposited 21 eggs which hatched at

noon, August 3rd, the resulting thirteen adults emerging from the soil at 10 A. M., August 26th and 27th, and constituting the parents of the third generation, which unfortunately was not carried through to the adult stage, though larvae were obtained from the 96 eggs deposited by them. The following schema and table represents graphically these generations reared in confinement. Other relative data are given in connection with a preceding table (table II).

SCHEMA OF GENERATIONS REARED IN THE LABORATORY, NEW RICHMOND, OHIO, 1907.

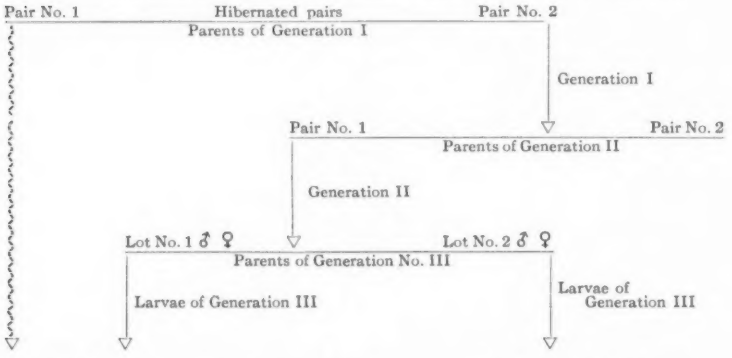


TABLE X. GENERATIONS REARED IN THE LABORATORY, NEW RICHMOND, OHIO, 1907.

Generation No.	Eggs deposited.	Adults out.	Length of cycle.		Effective temperature, sum.
			Days.	Hours.	
I.	1 p. m., June 20th.	12:30 p. m., July 17.	26	23½	897.2° Fahr.
II.	1 p. m., July 29.	10 p. m., Aug. 26.	28	9	*
III.	Sept. 2–4.	Not reared to maturity.			

* Not obtained.

It is interesting to note in connection with the third generation, that although in itself not reared to maturity on account of the lack of opportunity, yet an almost parallel cycle was obtained from a series of 13 larvae hatching at 8 A. M., August 30th, from eggs deposited by Pair No. 1, hibernated individuals or parents of the first generation, and coming to maturity at 10 A. M., September 25th; this generation of larvae was not more than four or five days earlier than the third generation. There can be no doubt that the parents of the third generation (or the adults of the second generation) were willing to reproduce to some extent

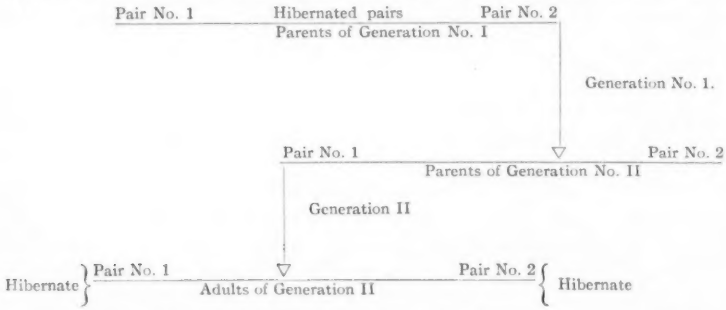
before going into hibernation, and there appears to be no reason why the larvae so produced should not have reached maturity with ease. It seems perfectly reasonable to me to have reared at least three, if not four, complete cycles of this insect during the season, if the breeding had been started about the first of June, instead of more than three weeks later, as unfortunately was the case.

Although the foregoing looks clear enough to me, but because of the conditions being those of confinement and on so small a scale, I approach with caution the statements of Tower (1906, p. 243), on the number of generations in Leptinotarsa decemlineata. Quoting directly from this work, he says: "The number of generations in Leptinotarsa each year, in both temperate and tropical latitudes, is a remarkably constant character, and might well be used as a generic differential. As far as I know, the number in all of the species is limited to two. Thus, there are two generations throughout the range of decemlineata, although Lugger has recorded three in Minnesota, and others have supposed that there may be three in the southern United States. I have not, however, been able to get decemlineata to breed more than twice in a season without a period of hibernation or aestivation. In the spring decemlineata emerges from the ground, and after a period of feeding, during which the germ-cells are also maturing, it breeds and lays the eggs for the first generation. These are usually all deposited at about the same time, but there are always for a month or more some individuals that are laying eggs, and of course the larvae and imagines resulting from these eggs which are last laid are much later in maturing than are the majority of the population. The first brood, on emergence, feeds for a few days, and then deposits the eggs for the second generation. The majority of these eggs hatch late in the summer, and after the animals feed and fly around for a month or more they burrow into the ground, and there hibernate until the following spring. The second generation does not develop the germ-cells nor show any reproductive activity until after it has passed through a period of hibernation or aestivation. Beetles are found breeding even late in the autumn, but these are the belated individuals of either the first or second generation. As far as I can discover, the life cycle in this species is that given above." Further down on the same page, he says: "The species in the genus are therefore double-brooded, the second brood undergoing hibernation or aestivation before reproductive activity is re-

sumed." And again on page 244: "In all the species of the genus the only difference between the two generations is that the second does not develop the germ-cells until after a period of rest, while the other develops them at once, or soon after emergence."

Although these statements are not very clear to my mind, because of certain ambiguities*, yet the following schema represents my interpretation of Tower. This schema, for the convenience of comparison with the one in foregoing (p. 168), is based on two pairs for each generation.

SCHEMA REPRESENTING AN INTERPRETATION OF TOWER'S GENERATIONS OF DECEMLINEATA.



By comparing the two schemata, it is at once apparent that a portion of a third generation is represented by my observations, and this is clearly in disagreement with the reiterated statements of Tower, to the effect that the adults of the second generation do not breed, or even show signs of breeding, before a period of hibernation or aestivation. This fact would not be considered of much importance, owing to the laboratory conditions and meagreness of the observations, were it not for the statement made by Tower (*Ib.*, p. 246) that "In decemlineata I have not by any process been able to prevent this preparation for hibernation in beetles which should normally hibernate." The mating and reproduction of the adults of the second generation are therefore very,

* For example, the two successive sentences on page 243: "The *second generation does not develop the germ-cells nor show any reproductive activity until after it has passed through a period of hibernation or aestivation.*" and "Beetles are found *breeding* even late in the autumn, but these are the belated individuals of either the first or *second* generation." It is clearly implied in the last sentence that beetles of the second generation breed, which flatly contradicts the declaration of the first; there exists a confusion of terms both here and elsewhere in the discussion. The italics here are mine.

very exceptional, according to Tower, for it is implied that he was unable to find such either under a great variety of natural habitats, or under all possible laboratory and experimental conditions. Hence it seems all the more strange that these phenomena should occur from the first under ordinary laboratory conditions, in a breeding experiment which was purely incidental.

But Tower does not give all of the matter concerning this question together, and it is in the later portion of his work that we find the most pertinent data on it. This is in relation to the production of special races by breeding under controlled conditions.

If a race can be considered the same as its species, Tower practically admits that there *may be* on occasion, more than two annual generations, and thus contradicts himself, for he says on page 251: "Closely associated with the hibernation of the second generation in these beetles is the quiescent or resting period in the cycle of the germ plasm. That is, the germ cells do not develop at all in the autumn, but remain as oocytes or spermatocytes, which are relatively few in number, until the following spring after emergence from hibernation, when they develop rapidly. This period of inactivity in the reproductive elements has been regarded as due to some inherent necessity for rest in the germ plasm. However, it does not seem to me to be of this nature; it is rather in the nature of a very deep-seated adaptation, like aestivation, which has been developed and retained not only in this genus, but also in the whole insect phylum, for the purpose of enabling them to pass successfully over the season of the year when unfavorable conditions of existence are most apt to occur. In my experiments a race arose suddenly in which there were five generations, and then a period of rest, and then five more, and so on." From this quotation, it is apparent that Tower obtained five seasonal generations with what he calls a *race* of the *species* decemlineata. I believe, however, that the distinction is justifiable because the appearance of the individuals with five annual cycles, under controlled conditions in confinement, was relatively scarce, abnormal, and they had racial characteristics.

Again, Tower (*Ib.*, pp. 280–281) gives another illustration of the occurrence of more than two annual cycles: "A variation which arose from decemlineata obtained at McPherson, Kansas, appeared in my culture in June, 1904. This was rubrivittata,

of striking form and coloration, of which there was a single male. The parents, which were collected in July, 1903, near McPherson, Kansas, were sent to Chicago and reared in a second generation which was normal; they hibernated until May, 1904, and then emerged, reproduced, and among the progeny was this single male rubrivittata. This male was crossed with a female decemlineata from Chicago, and gave a hybrid brood intermediate in character between the parents. Three males and one female of this lot escaped the general extermination of my experiments in July, and were carried over into 1905, giving after transfer to Mexico in March, 1905, a Mendelian splitting into typical rubrivittata and hybrid forms (text—fig. 22). These were separated and reared. The pure cultures of rubrivittata showed as a result a new character, namely, that its life-history as well as less important characters were changed, there being three generations in its yearly cycle instead of two, as in the parent species, and in all of the species in its immediate ancestry.

"This change in the life cycle from hibernating in every second generation, as do most of the species in the genus, to hibernating in every third, is striking and significant, the three generations being gone through in about the same time as the two of the parent species. The cultures with rubrivittata demonstrate clearly that *changes in physiological characters can take place rapidly, as do changes in structure*, and that these changes may alter not only unimportant characters, but most fundamental ones as well. We shall have occasion to consider a similar case even more striking and interesting in a later portion of this chapter."

The remaining case referred to in the last sentence of the quotation just ended (from pp. 280–281) is now given for convenience and in order to place all of them as near together as possible; space does not allow of its being given in full, and I give a brief history of it until the variation appears. Beetles emerging from hibernation in May, 1901, (Tower, Ib., p. 288) were reared until May, 1902, under normal conditions without extreme variation. They were then divided into two lots and subjected, one to hot and dry conditions, and the other to hot, dry and low pressure conditions. The first is considered.*

"From the apparently pure stock, 7 males and 7 females were in May, 1902, subjected during the first half of their reproductive

*The other lot appears to have been ignored, though a statement is made to contrary (p. 288).

period to hot, dry conditions, during which time they laid 409 eggs. For the latter half of the reproductive cycle they were kept in normal conditions, laying 840 eggs, From the 409 eggs developed and laid in changed surroundings I obtained 64 adults, as follows:

"A(1) Normal (apparently) decemlineata, 12 males, 8 females; (A 2) L.pallida, † 10 males, 13 females; (A 3) L. immaculothorax,* 2 males, 3 females; and (A 4) L. albida,† 9 males, 7 females. These four lots were separated and reared, with the exception of pallida. The 840 eggs laid in normal conditions gave 123 normal decemlineata, and these I designated B.

"The Lots A1 and B were reared side by side in the following generations and both gave normal beetles as far as could be determined, but as the period for hibernation approached, those of A1, instead of going deep into the ground, as did B and as is normal, aestivated on top or close to the top. The Lot B went into hibernation in September, A 1 in late October and early November. In January (January 2) Lot A 1 emerged from aestivation and began breeding, giving a brood, part of which hibernated and part continued breeding for five generations, then hibernated, and then emerged and bred through five more generations. These hibernated again, and in the fourth generation of the third cycle of five generations were killed in July, 1904. These successive generations were all reared under exactly similar conditions, nor‡ was there any conscious selection practiced. Free interbreeding in each lot was allowed. The general result is expressed in text-figure 26.

"This race with a cycle of five generations is of great interest, showing the profound modification resulting in the reproductive cycle. None of the beetles of the lineata group, to which this beetle belongs, have more than two, or rarely three generations per year, and there are none known in the genus that have over three. Clearly, then, this race with five generations in each cycle is quite a new character in the genus, and was, as far as discovered, constant‖ from the start, showing in the fourteen generations no tendency to revert to the parental standard. As far as I can discover, this case can be explained only as the direct response of the germ plasm to the extreme stimuli used in the experiment.

* L. decemlineata pallida Tower; L. decemlineata immaculothorax Tower.
† L. decemlineata albida Tower. (Cf. p. 92).
‡ Beginning p, 289.
‖ Beginning p. 290.

It seems impossible to account for the condition produced upon the basis of a latent character of this kind somewhere in the ancestry of this genus. Moreover, all of the beetles in this experiment had an equal chance to be accelerated by the conditions of existence, so that this factor could not by any stretch of the imagination be held to account for the development of this change. As far as is known, the only changed factor in this experiment was that used in the third generation upon the 7 males and 7 females for three-fifths * of the reproduction period†. From the germ cells subjected to stimuli this race arose, but not at once, two generations being necessary in which to disentangle the changed character from the non-modified decemlineata."

Therefore, in order to agree with Tower's results, the production of eggs by the adults of the second generation of the beetles reared by me in 1907, will have to be considered as due to some abnormal stimulus present during maturization of the reproductive elements, or as a racial characteristic; but it seems to me that either supposition is improbable, because of the few generations through which the beetles had been inbred. Tower's evidence is poorly presented, without reservation or limitation in places, it is contradictory and it is to be regretted that in a great many places he has contented himself with giving general statements without the accompanying data as evidence; conditions that produce controversy instead of establishing fact. When his evidence is sifted, however, it is found that the following facts are indicated as being true:

1. That decemlineata, when bred in confinement in normal environments, in all cases goes through but two annual cycles the second of which hibernates before reproduction.
2. That decemlineata, when bred in confinement through more than three generations in abnormal controlled environments, in the great majority of cases goes through but two annual cycles, as in normal beetles.
3. That the species, when bred in confinement for more than three generations in abnormal controlled environments, exceptionally may go through as many as five annual cycles, this physiological variation being correlated with morphological variations of racial value, produced suddenly.

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* One-half? (Cf. Statement of conditions, p. 288).

† A foot-note follows here, which is omitted in the quotation.

These being true, the facts recorded by me in regard to the production of a third generation are indeterminate in value, and exceptional in nature, for apparently there were neither abnormal environmental factors present, nor variation tending to racial evolution. It would be highly interesting and important, therefore, if more of this breeding of annual cycles under normal or natural conditions, was carried on, in two similar series, in the laboratory and in the field under as natural conditions as possible. The question of the number of annual generations of decemlineata freely breeding in nature has not been determined yet by actual experiment, or at least such are not recorded with cold evidence, and Tower (1906) has not decided it, but perhaps left it in a more controversial position than ever; he has, however, made a long stride in the direction of settlement.

But looking at it from another standpoint, I believe that Tower (1906), although in the proper place (Ib., Chapter IV, p. 243) not presenting definite data upon which his conclusions are based, has the best right to be followed because of his large experience with breeding the species in question. As I understand it, he speaks of normal, average conditions in nature, and I do not know that any direct or definite evidence has yet been presented to show that the species is more or less than double-brooded in nature, and Tower certainly has had enough experience with decemlineata in nature to speak with authority on the subject. There are certainly as many as two annual cycles, if repeated laboratory experiments can be at all trusted, and Knab's (1908) recent contention that there is but one, based on the systematic relations of the beetle is not tenable, and to my belief, wholly without basis or foundation for advancement. The question now is: Are there but two, or more than two annual cycles with decemlineata; or, in other words, does the second generation reproduce? This does not concern any other species of Leptinotarsa or species of Calligrapha, Lina or Gastroidea, but the sole species under consideration.

I have myself recorded reproduction by a first reared generation of Gastroidea cyanea Melsheimer (Girault, 1908, p. 8), making two annual cycles possible, but I can't see what the number of generations in closely related genera of the family has to do with the question at issue, especially since the question with these genera is not established. It was also going beyond the point to say that the seeming double-broodedness of decemlineata "may

be due to the difference in time of emergence from hibernation of different individuals," for Tower (1906, pp. 202, 266–267, *et al.*) gives evidence by direct breeding, thus throwing this out of the question.

And summing up, all of this discussion but again calls attention to the crying need for facts. We want tangible evidence, not inductions, views, opinions, or claims.

6. *Behavior of Adults in Confinement; Hibernation.* The pairs kept in confinement, normally reproducing, behaved in some instances peculiarly; this was especially noticeable in the case of the male of one of the hibernated pairs. In pair No. 1 of the hibernated beetles, the two sexes behaved normally until on July 2nd, the male disappeared and was found on the morning of July 3rd buried beneath the soil; it was replaced on the surface but again went beneath after several hours had elapsed. It was exhumed again at 3 P. M., July 6th, and was again beneath within the following hour, and the same fact holds for 10 A. M., July 9th. It was re-exhumed at 5 P. M., July 15th; 3 P. M., August 5th; August 19th (A. M.); 11 A. M., August 28th, September 2nd, October 17th and 23rd, each time re-entering at once and paying no attention to the female or food. On November 1st, it was again disturbed and given fresh quarters for hibernation; it finally emerged (it was kept in a cold room) on February 26th, 1908, and died on the following April 6th; it had apparently hibernated during two winters, that of 1906–1907 and 1907–1908.

The male of pair No. 2 of the hibernated pairs behaved normally until its death at 5 P. M., August 16th. The male of pair No. 1 of the first generation entered the soil P. M., August 5th, and the female P. M., August 7th; both were exhumed alive at 10 A. M., August 19th and replaced on the surface with fresh food which they ignored and re-entered the soil. They were exhumed alive on November 1st and liberated. The male of pair No. 2 of this generation entered the soil A. M., August 7th and was exhumed at 10 A. M., August 19th; it at once re-entered. On August 22nd, the female of this pair entered the soil, and at 10 A. M., September 2nd, both were exhumed alive and replaced on the surface of the soil into which they soon disappeared. On October 17th and 23rd, the exhumation was repeated with similar results; they were dug up alive and liberated on November 1st, 1907, with the other pair. In Lot No. 1 of the second generation, 2 entered the earth on September 7th, and on the 9th of the same month

the remaining beetles entered (between the two dates, their food had of necessity been neglected and had wilted); on October 17th the seven were exhumed alive and placed on the surface of the soil into which they had disappeared within an hour. They were exhumed alive and liberated with the others on November 1st. The adults of lot No. 2 of this generation entered the soil together on September 12th, and were undisturbed until liberated on November 1st, all in good health and hibernating.

Even when entering the conditions of hibernation in the warm summer months, it seems almost impossible to break into the habit and induce the beetles to feed or mate. Their physiological condition must be profoundly modified in this state, as has been found to be the case by Tower (1906, p. 245ff.)

General Field Conditions, Supplementing the foregoing.

I was unable to watch the beetles in the field at all closely, so that but a few fragmentary observations were made; these will serve, however, to give some idea of the general conditions prevailing with the species in the late summer of 1907. It should first be stated that the season of 1907 was very abnormal, in that the spring was at first far advanced in March, it then being very warm, and later in April retarded by a cold wave which killed young plants and newly set fruit or the far advanced fruit buds; planting was therefore much delayed in many cases, but data kindly gathered for me by the Reverend Mr. C. L. Chapman of New Richmond, showed that the potato crop was at least an exception. The following table compiled by Mr. Chapman shows the relative times of planting and harvesting of the potato crop in the vicinity of New Richmond, Ohio, for the three seasons past.

TABLE XI. Relative Times of Planting and Harvesting Potato, 1905–1907.

Year.	Preparation of Soil.	Time of General Planting.	Time of Harvest.
1905.	March 27–April 20.	March 30–April 30.	September 1–October 1.
1906.	April 1–April 20.	April 13–20	July 20–August 31.
1907.	March 25–April 15.	March 29–April 20.	September 30–October 10.

From the table, it appears that the crop remained in the field somewhat later than usual in 1907, and this would apparently have some bearing on the breeding of the beetles.

On September 2nd, 1907, it was noted that adults were still mating in numbers, and larvae were also abundant; this observation made in a single field. On the 6th of the same month in the same field adults and large larvae were numerous, but eggs were relatively scarce; several egg-masses were found, however. On September 25th, a long search in this field failed to find either eggs or larvae, and but very few adults and these were extremely restless. I find unfortunately that these fragments are all that were recorded, and they leave much to be desired.

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